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ENCKE'S COMET.

ON THE POSSIBILITY OF PHOTOGRAPHING THE COMET AT ALL POINTS IN ITS ORBIT.

E. E BARNARD.

The comet was rediscovered here photographically with the Bruce telescope on 1914 September 17. It was photographed on several subsequent dates. The following positions are derived from measures of the plates taken with the 10-inch lens. Two or three comparison stars have been used in each case. The comet was faint and difficult with the lowest power on the Gaertner measuring machine. It could not be seen with the 5-inch guiding telescope, and the guiding was done on a star. The center of the comet's trail was measured.

POSITIONS OF ENCKE'S COMET FROM PHOTOGRAPHS TAKEN WITH THE 10-INCH BRUCE LENS OF THE YERKES OBSERVATORY.

1914	G.M.T.			α 1914.0			δ 1914.0		
	d	h	m	h	m	s	°	′	″
Sept.	17	18	2.7	3	43	31.7	+37	51	27
"	18	17	54.7	3	45	55.1	+38	20	50
"	19	19	3.1	3	48	28.8	+38	53	22
"	20	18	12.1	3	50	58.2	+39	22	42
"	22	19	1.5	3	56	36.5	+40	30	36
"	24	18	44.5	4	2	32.8	+41	41	10

In later photographs of the comet, it was easily visible in the 5-inch guiding telescope. Several photographs have been obtained of it by guiding on the comet. Two sets of plates were thus obtained on October 26, with an exposure of one hour in each case. All these show a thin thread-like tail nearly one degree long, slightly curved and extending northwest. On these photographs the comet is quite well defined on the north following side, where the center of brightness is, and very diffused to the southeast, as if there was an effort to form a tail in that direction, but, strangely enough, the slender tail lies in exactly the opposite direction, producing thus a very odd look. The tail is not visible on the photographs of October 29, though twice the exposure was given, nor is it shown on November 8 with 47 minutes exposure, although this is a poor photograph on account of moonlight.

At the observations of October 26 and 29 with the 5-inch, the comet was perhaps of the eighth magnitude or less, and unsymmetrically but not very strongly condensed. The condensation was on the north preceding side. On November 8 it was round, strongly and symmetrically condensed and decidedly brighter than on October 26 and 29. It was estimated to be of the seventh or eighth magnitude. No nucleus was visible in any of the observations, nor was the tail seen. On none of the dates was it visible with the naked eye.

On the original negative of October 29 the comet is large and diffused. Its extreme measured diameter is 18′ 44″. This corresponds to a diameter of 148,000 miles or 238,000 kilometers.

In the early history of this comet it was seen with the naked eye at several returns and at times a tail has been visible in the telescope. Chambers, in his *Handbook of Descriptive and Practical Astronomy*, Vol. I (Edition of 1889) gives quite a complete and historical account of the appearances of the comet at its various returns up to 1888. He dismisses the return of 1885 with the brief statement that "it was observed by Tempel on December 13, [1884], but it was extremely faint." At that return the comet passed perihelion on 1885 March 5. It was a bright object in a small telescope and had a considerable tail. In *The Observatory* for April 1885, Volume 8, p. 122, the present writer has given an account of the appearance of the comet then, with a drawing which shows a considerable tail as seen with a five and six-inch telescope on 1885 February 13, at Nashville, Tenn. I quote from the article.

"This comet has been observed here frequently since January 2, mostly with the five-inch telescope while comet seeking. On the night of February 11 a faint tail was noticed at about 7 P.M.; this extended some 10′ in a direction slightly *n.f.* The tail pointed directly towards and nearly reached an eighth magnitude star in the same field with the comet.

"On the night of February 13 a careful examination of the comet was made with the six-inch Cooke Equatorial of this [Vanderbilt] observatory and the enclosed sketch secured. The comet was small and brightly condensed; the point of greatest brightness was not central, but very slightly following the center in the direction of the tail. The tail was very slender, faint, and straight, and extended about 14′ or 15′, by estimation, in a direction about 20° north of following.

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"On February 16 the tail to Encke's comet was a little longer and slightly more distinct than on the 13th. The general appearance of the comet was the same as on the 13th."

The foregoing general description agrees with the photographs made here on 1914 October 26 in showing that the condensation was on the same side of the comet as the tail.

PLATE XXIX

ENCKE'S COMET (ENLARGED) 1914 OCTOBER 29, $16^h\ 2^m$ C. S. T.

Exposure $1^h\ 53^m$. 1855.0 $\alpha\ 12^h\ 14^m\ \delta + 42\frac{1}{2}°$. 10-inch Bruce Telescope.
Yerkes Observatory. E. E. Barnard.

Scale: { 1 inch = 32′.8
1 cm. = 12′.9

Some time ago it occurred to me that Encke's comet might be photographed at aphelion with the 60-inch reflector of the Carnegie Institution at Mount Wilson. Mr. F. E. Seagrave kindly computed an ephemeris of the comet near the time of aphelion from his elements of its orbit. According to Mr. Seagrave, aphelion occurred 1913 April 12. The matter was brought before Professor Hale and Mr. Adams, and on 1913 July 2 Mr. Pease made an exposure of $2^h\ 7^m$ on the position of the comet with the 60-inch telescope. This original negative was forwarded to me by parcel post. It was lost in the mails and all effort to find it failed. Mr. Pease then made another exposure on the ephemeris position 1913 September $1^d\ 20^h\ 40^m\ 51^s$ G. M. T., giving a total exposure of $3^h\ 32^m$. In this plate allowance was made for motion, so that the entire exposure was on the comet. This photograph showed a suspicious object, but there was some uncertainty as to the exactness of the ephemeris. This uncertainty has been removed as far as possible by Mr. Seagrave, who corrected his orbit with the aid of the photographic positions given in this paper. This brings the position of the comet very close to that of the object on Mr. Pease's photograph. There is a strong probability that it is Encke's comet, but it is not certain. With the aid of known stars on the plate I have measured the position of the object with the Gaertner measuring machine. Following are this position and the ephemeris place assigned by Mr. Seagrave:

60-inch Reflector Plate	1913.0	$\alpha\ 23^h\ 10^m\ 25^s.1$	$\delta\ -1°\ 42'\ 34''$
Ephemeris Place	"	$\alpha\ 23\ 10\ 30.5$	$\delta\ -1\ 42\ 1$

This is 142 days after aphelion. If it is the comet, it shows that there will be no trouble in photographing it all around the orbit with the 60-inch telescope, for the image is quite strong on the original negative.

As there is necessarily some uncertainty as to the identity of the object with the comet it will be important to verify it by similar photographs with the 60-inch when the comet is favorably placed near aphelion. According to Mr. Seagrave the next aphelion occurs in July, 1916, when the comet is near opposition. This will make a photographic search for it specially favorable.

I am greatly indebted to Professor Hale and Mr. Adams for their interest in the matter and to Mr. Pease for the excellent photograph of the comet's place. I am also greatly indebted to Mr. Seagrave, who has given every assistance in his power in supplying me with ephemeris places of the comet from his accurate elements, from which the comet was finally found.

On 1914 August $3^d\ 21^h\ 0^m$ G.M.T., Mr. H. L. Alden made a photograph of the region of the comet with the 2-foot reflector of the Yerkes Obser-

vatory, with an exposure of 80 minutes, guiding on a star. An object is shown on his plate in the following position:

Object	1914.0	α 2^h 30^m 52^s.3	δ + 24° 5′ 6″
Ephemeris place of comet	"	α 2 30 33	δ + 24 17 25

It is thought best to record this observation in the hope that it may possibly prove to be the comet.

Yerkes Observatory,
Williams Bay, Wisconsin.
1914, November 17.

PROBABLE ERROR OF OBSERVATIONS OF FAINT STARS WITH THE MERIDIAN CIRCLE.

R. H. TUCKER.

Progress in a scheme of meridian observing may appear to be quite monotonous, and the general character of the work to be largely routine. The interest of the observer is fixed upon perfecting every detail of instrumental performance, upon keeping his own faculties under reliable control, and finally upon making some contribution to the knowledge of masses of star positions, which may lead to the better knowledge of stellar motions, and to that of the solar system.

Accuracy in detail and in the mass are prime essentials, and an early test of this quality may prove stimulating to the observer, and helpful in sustaining the attention, which faculty should never be allowed to flag. There is no other factor more important in observing, and fortunately one's attention is susceptible of training, until it becomes a reliable habit, the most useful habit one can form in life.

Some description of the tests of the accuracy of meridian work, and of their bearing upon final results may have interest for the general reader, who rarely considers this class of observatory work in the presence of the many investigations in astronomy which have more striking features of appeal. There are no discoveries to be anticipated, unless the first knowledge of perceptible proper motions in stars, for which none had been previously determined, can be classed as discovery. This knowledge comes from the comparison of results with older observations, and will become more extensive as the study of exact positions of the faint stars is continued. The bright stars have been so well observed that material exists for the determination of proper motions, in all save those of very slow changes.

A list of 600 stars is being observed with the Lick Observatory Meridian Circle, in the current year. These are all telescopic stars, classed as faint in comparison with naked eye stars, but susceptible of precise observations. With the plan of making two observations of each star in the two positions of the instrument, clamp east and clamp west, with the accompanying fundamental stars, circumpolar stars for azimuth, and the nadirs, about four thousand observations are required.

The first check upon the accordance of separate observations is obtained by comparing the transits and circle readings for two nights when the same programme of stars is observed. This check is usually applied immediately after the means of the observations of the second night of a pair of nights have been taken. It has immediate usefulness in testing every detail of the observation, and of the computation to that point, so that the mean results are ready to be transferred from the observing book to the computation sheets, after every single thread of the transit, and every single microscope reading on the circle has had its proper scrutiny. Since the stars of the present list do not differ much in declination, the differences of individual transits and circle readings will indicate, by their residuals from the mean differences, very closely the differences which will eventually appear when all the corrections shall have been applied, to obtain actual positions of the stars. This test is so close that any mistakes of computation will be very certainly detected, in any part of the reduction, by carrying forward these first residuals for reference. This is important as a time saver, and in the case when there is no extra computer to follow through the operations in detail. The first series of residuals may be expected to slightly exceed the later residuals, especially if the interval between the nights is large, for the reduction to the beginning of the year may then give more appreciable variations than do the instrumental corrections for the two nights. The check may serve to indicate at once the need of further observations, if an abnormal residual is encountered; and when no such abnormal residuals appear, the general satisfactory progress of the work is as clearly indicated. The mean residual for the faint stars may differ from the mean difference for the group of fundamental stars, of approximately the same average declination. This indicates a final average difference for the two nights of observation in the positions of the faint stars.

This average difference has some features of a systematic character, and has sometimes been treated as systematic error in the discussion of observations made with the meridian circle, and in other classes of observation. Often the explanation should be sought in sources of accidental, rather than systematic error. Thus, each observation of a fundamental star is subject to accidental error, and the probable error

of the mean of a group of fundamental stars can be closely predicted. The probable error due to the difference between the observations of the same group of fundamental stars, on two nights, can also be predicted, and computation will confirm the prediction. Whatever residual appears in the comparison of the observation of the two nights, for the fundamental stars, will finally appear as an average difference in the reduced places of the faint stars. As long as this residual does not exceed the size which experience shows us may be anticipated, in the observation of the fundamental stars, there is no indication of error of a systematic character. The two night's observations of fundamental stars may give a residual of very small size, and in this case there would be a negligible difference in the average agreement of the observation of the faint stars, while their accuracy would really be not appreciably greater. In practice, the test of observation by means of the probable error, deduced from the residuals, must always be used with discretion and interpreted with judgment. The figures, alone, can be misleading.

In the current comparison of the precision of individual observations, it is of interest to notice if the weight attributed to the night, depending upon the quality of the observing conditions, has any direct effect. Observations are more difficult on nights of inferior weight, but it has been my experience, in general, with meridian circle observations, that the final results do not exhibit much deterioration with the lower weights. The extra attention, and even the judgment required in observing under difficulties appear to compensate for the inferior natural conditions. This has been proved by the comparison of results, and was not a preconceived opinion.

Our system of weights at the Lick Observatory is similar for all the observers who do visual work. In the photographic work, clearness and transparency of sky are the principal sources of variation. In the spectroscopic work, now practically all photographic, some variation would be introduced by marked unsteadiness. In double star measures, definition is a consideration perhaps more important than unsteadiness, though it is rarely that one of these qualities is to be ranked as very inferior without the other quality of the seeing being also bad. In meridian circle work, steadiness is the main consideration in estimating the quality of the night, and my estimate is usually made upon a star of low altitude, such as a circumpolar at lower culmination, for the differences in quality are naturally most noticeable at low altitudes. Occasionally the quality and steadiness may differ somewhat on the two opposite sides of the zenith, but this difference is very rarely pronounced, and, in general, the weight of the night is the estimate at the worst observation of one of the lowest stars.

The scale adopted runs from one to five. Some observers rank weight five as theoretically perfect, and consequently never attribute this weight to any observation, nor to any night. My own practice is to give weight five to the best conditions we experience here, and in the course of many years of observation it is not difficult to decide what constitutes as good conditions as are realizable. On the other hand, weight one is so bad in my estimation that I would ordinarily suspend work under such unsatisfactory conditions, unless the need of securing some special observation was imperative. In daylight observations, during work of a fundamental character, many of the observations were of weight one only. They were often worse than I have ever seen observations here at night. Below that unit of weight I should consider observing as practically impossible. Some of the observers go farther, and split the scheme of weights into fractions, estimating the seeing as plus three and minus three, for instance, for nights slightly better or worse than weight three. This is really equivalent to using a scale of a dozen or more variations of quality, a refinement which may serve to indicate the relative power of the instrument in fine subdivisions.

In general, I would say that weight three indicates the average conditions, satisfactory in quality for anything but very exacting requirements. Nights of weight two are somewhat unsatisfactory, and the observations are difficult. Weight one would be decidedly unsatisfactory. Weight four would be fine, and entirely satisfactory, though not up to the supreme tests of instrument and observer. Weight five, for the meridian circle observer at least, would indicate the quality of our best nights, when scarcely an imperfection of any character is evident. We occasionally experience such conditions here. This does not mean that stars at the lowest altitudes permit of the same precision of observation as those of reasonably large zenith distance, for one must be governed by the bounds of what is attainable.

As a concrete illustration of the observing conditions and of their effect upon the precision of the results, the tabulation that follows includes eight months of this year, up to the end of September, beginning at the end of January.

There are 71 nights on which observations were made on the programme, three of which were broken off and completed at a later date.

This affords 34 pairs for the comparison of differences for the residuals, which in turn give the probable errors.

In the bad weather of the late winter and early spring, nearly all the available nights were used. In the good weather of the summer, one third of the nights are sufficient to keep up the observing programme.

During this interval, I find that I have rated the observing:

4	nights	of	weight	5 =	6 %
27	"	"	"	4 =	38 "
30	"	"	"	3 =	42 "
10	"	"	"	2 =	14 "

This is rather a large proportion of nights of above average conditions, but I find some nights rated as four as early as February and March; and often the bad nights can be omitted, without reference to the telescope to determine the observing conditions. For comparing the relative precision of the observations under different conditions, there are the following combinations, for pairs of nights.

				P.E. diff. R.A.	Decl.
				s	
Weight	2	and weight	2	±0.037	±0".27
"	2	" "	3	0.037	0.37
"	2	" "	4	0.028	0.30
"	2	" "	5	—	—
"	3	" "	3	0.033	0.33
"	3	" "	4	0.033	0.31
"	3	" "	5	—	—
"	4	" "	4	0.033	0.28
"	4	" "	5	0.035	0.32
"	5	" "	5	—	—
Means				±0s.033	±0".32

The average probable errors of a single observation, based upon the above residuals, would accordingly be: ±0s.023 and ±0".22. This does not include the effect of division error, which will be referred to later, for its effect upon the result of four determinations. No residuals were rejected in making this current calculation of probable errors. It is always risky to base the rejection of residuals upon a small number, and while a large mass of observations are finally discussed in the current test, the residuals appear in comparatively small sets. For as many as one hundred residuals, the established criterion of rejection may be valid; but, for sets of much less number, the practice should be to use the test mainly for the scrutiny of doubtful residuals, and to use caution in excluding any for which no mistakes are established. Considerable variation is noticeable in the comparison of the pairs of nights; but the feature which is especially significant is the lack of connection between the weights of the nights, and the apparent precision of the results. This is, however, in accord with the experience mentioned above, that the results are not necessarily perceptibly impaired by the difficulties of observing under the less favorable conditions. The average probable error is not much less than that found on comparison of the best nights, nor much in excess of that found for the nights below the average conditions. A conservative course in the treatment of residuals may be expressed in another form, for the illustration of the employment of probable error computations. The probable

errors may be used as a test of the observations; but the observations should not be employed as a test of the probable errors. A tendency towards the latter course has been responsible for some weird and unsound theoretical values.

The probable errors found by this method of comparing the pairs of nights are not likely to be exceeded in the final reductions, and they undoubtedly have included some variations in residuals due to the varied intervals of time. This is tested in the tabulation below, when the most favorable cases are combined in the shorter intervals, without regard to the weights of the respective nights. The variation of the instrumental corrections is nearly eliminated in either case, but the reduction to the beginning of the year is more subject to variation in the longer intervals, for this comparison, while its variations will be eliminated in the final reduction of the stars places.

	P.E. diff. R.A.	Decl.	Pairs
	s	″	
Interval of 1 day	±0.029	±0.29	9
" " 2 days	0.034	0.32	13
" " 3 and 4 "	0.035	0.32	7
" " more than 4 "	0.035	0.35	5
weighted means	±0ˢ.033	±0″.32	

The increase in probable error is quite distinct for the longer intervals, and it is quite certain that the probable errors of a single observation, when the reductions are fully completed, will be found not to exceed ±0ˢ.022, and ±0″.21, in Right Ascension, and Declination, respectively. Since the observations in Right Ascension are not usually found to exhibit any systematic error, depending upon the position of the instrument, in our earlier sets of determinations, the probable error of the mean of four observations can be predicted as likely to be ±0ˢ.011, or 0″.17. In declination the probable error of the final result must take account of the division error of the circle. This has been measured, and has been found to be quite exactly ±0″.15, for a reading upon the mean of four divisions. Accordingly, the mean of the two positions will be affected by a probable error of division of ±0″.10, and the final declination from four observations will have a probable error of ±0″.15, practically about the same precision as that reached in the observations in the other coördinate, Right Ascension. In individual cases, the precision of the one coördinate is often found to be relatively much greater than the other. Some of the smallest residuals in Right Ascension may appear in comparisons which show residuals in declination above the average; and the contrary relation also appears. Such differences are merely the natural effect of the observing conditions, and confirm the validity of the computed probable errors, while indicating the lack of effects due to variation in the quality of the night, in the final results.

The stars of the list observed range in magnitude from 7½ to 9, the greater portion being fainter than eighth magnitude. They were selected to give well distributed points of reference for the measurement of photographic positions of faint stars in a zone, and in general the reference stars are of the fainter class usually observed with the meridian circle. I do not consider that the precision of my observations diminishes perceptibly for stars down to the ninth magnitude of the standard visual scale, which I always define as the scale of the visual *Durchmusterung*. This scale appears, from some evidence, to lack conformity with the results of the photometric measures, which subject has been elsewhere treated. And, of course, the photographic scale, though based upon this same standard visual scale, shows some deviations from agreement with it. For stars below ninth magnitude, the difficulty of the observing undoubtedly diminishes the precision of meridian circle measures, but stars of true 9.5 can still be well determined. A tenth magnitude is observed under such strain that the determination may be perceptibly less precise.

Some seventeen hundred observations have already been treated thus far in this test of precision, over two thirds of those required for the determination of the places of the faint stars of this list. With average residuals of $\pm$ 0^s.038 and $\pm$0″.37, the results for separate pairs of nights range from 0^s.021 to 0^s.058, and from 0″.27 to 0″.60, in Right Ascension and Declination respectively. Both the upper limits are of exceptionally large size, and yet these barely exceed one and a half times the average. The probable errors of the average of the residuals are $\pm$0^s.001 and $\pm$ 0.″01, respectively.

In measuring the position of a faint star on the photographic plate, from one of the reference stars determined with the meridian circle, it is evident that the probable error of the adopted position of the reference stars may be slightly in excess of $\pm$ 0″.2, treated by the system of polar coördinates.

Lick Observatory, Sept. 30, 1914.

PLATE XXX

1
1877, Oct. 14
Dec. 28

2
1879, Oct. 28
Feb. 1

3
1882, Mar. 13
May 2

4
1884, Feb. 19
May 12

5
1886, May 21, 22
July 12

6
1888, June 5
Aug. 9

REPORT ON MARS.—No. 7.

WILLIAM H. PICKERING.

Ever since the writer first observed the canals of Mars in 1890, he has felt the need of some method of accurately measuring their breadth and darkness. The filar micrometer is of no use at all. First, because the mere superposition of the threads upon the surface of the planet causes all fine detail in their vicinity immediately to disappear, and secondly because the breadth of the finest spider web as compared to that of a martian or lunar canal is, to use a homely comparison, as a broomstick to a telegraph wire. The only method of measurement that has hitherto given results that are at all satisfactory consists in making careful drawings of the canals which can later themselves be measured. This plan however, while more or less successful with canals over one hundred miles in width, gives very unsatisfactory results with canals that are narrower. Indeed the results are little better than guesswork, based on estimates of relative visibility.

A simple plan lately occurred to the writer which has proved very successful in the case of the moon, but which was devised so recently that only one comparison with the Martian markings was possible before the planet retired beyond the range of practical observation. It consists simply in attaching to the side of the telescope near the object glass, and at right angles to its axis a paper scale, with canals of varying width drawn upon it. These are illuminated by a 5 c.p. tungsten light placed close to them, but screened from the eye of the observer. The observer himself simply looks alternately at the canal and at the scale, until he has made up his mind which division of the latter the canal most nearly matches.

The scale consists of six canals 30mm in length by 1, 2, 4, 6, 8, and 10mm in breadth, drawn with a No. 4 or H pencil. It is placed at a distance of 4.80 meters from the observer, so that with a magnification of 430 times, a breadth of 1mm corresponds to exactly 0″.1. One can readily interpolate to quarters of a division, for the wider canals, or to 0″.05. When Mars is at its nearest, this latter distance would correspond to nine miles (15 km), and it seems as if we should be able to measure the width of the canals, when well seen, by this means to that degree of accuracy with reasonable certainty. Measures made with different eye-pieces give independent results, which may later be compared. The lamp is placed 6.5 inches (16 cm.) from the scale, and with our 11-inch objective it is found that the brightness of the latter is

equal to that of Mars when viewed under a magnification of 430. At the time this observation was made Mars was practically at aphelion The scale was appreciably redder than the planet.

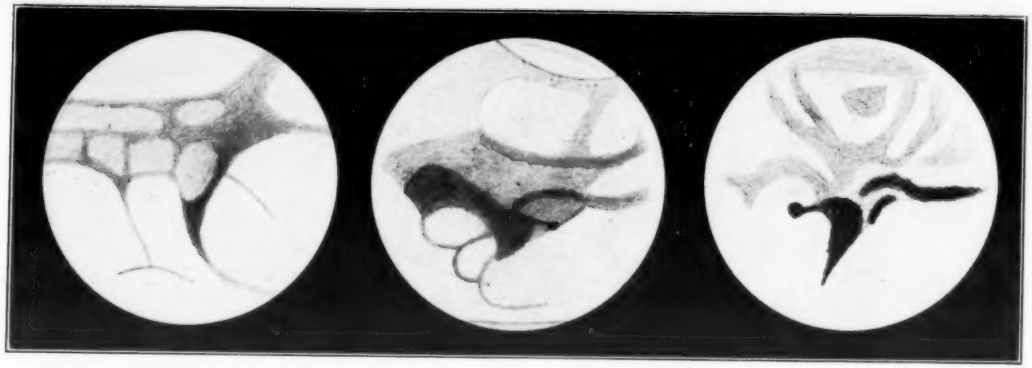
A similar scale may be used to measure the martian lakes. The one actually in use at the present time was prepared by comparison with the lakes of the moon, but since many of these appear exactly like those on Mars, there is no doubt but the scale will be found applicable when Mars again approaches us. This scale was drawn with a No. 3 or M pencil, the diameters of the circles being 2, 4, 6, 8, 10, and 12mm.

The first practical application of this was to the canals of the lunar crater Aristillus, described in the last number of POPULAR ASTRONOMY. When using a magnification of 430 with the 11-inch telescope, the diameter of the emergent pencil of light is one-fortieth of an inch. In order to make sure that a canal on a bright surface seen through a small aperture appears of the same breadth as an equal canal on a fainter and yellower surface seen with the naked eye, a special apparatus was devised. This consisted of a box five feet in length, divided by a longitudinal partition. Two similar scales of canals were employed whose widths were 0.25, 0.5, 1, and 1.5 mm. These were placed at one end of the box, one being illuminated by a tungsten lamp as above described, and the other by daylight coming through a hole in the side of the box, so arranged that its size could be regulated. When the latter scale was seen through an aperture one-fortieth of an inch in diameter, it was so illuminated as to appear of the same brightness as the other scale seen with the naked eye. The observer in the mean time sat in comparative darkness.

It was so planned that one scale should be viewed with one eye and the other with the other, but on account of the difference in my eyes it was found best to observe them alternately with my observing eye. When the canals were placed vertical or inclined from right to left the two sets of canals appeared of the same breadth. When they were placed horizontal, or inclined from left to right the canals illumined by the sky appeared slightly broader and fainter, the difference being equivalent to 0″.05 as measured in the telescope. It therefore appears that this method of measurement of the martian canals involves no large systematic error. On the other hand if we use a much smaller emergent pencil, of for example half the size, all of the narrower canals appear of the same breadth, differing from one another only in density. We must therefore avoid using too high a magnification in these measurements, for instance not over 40 or 50 to the inch of aperture.

Although it is the writer's custom in these articles to deal with the past rather than the future, an exception may profitably be made in

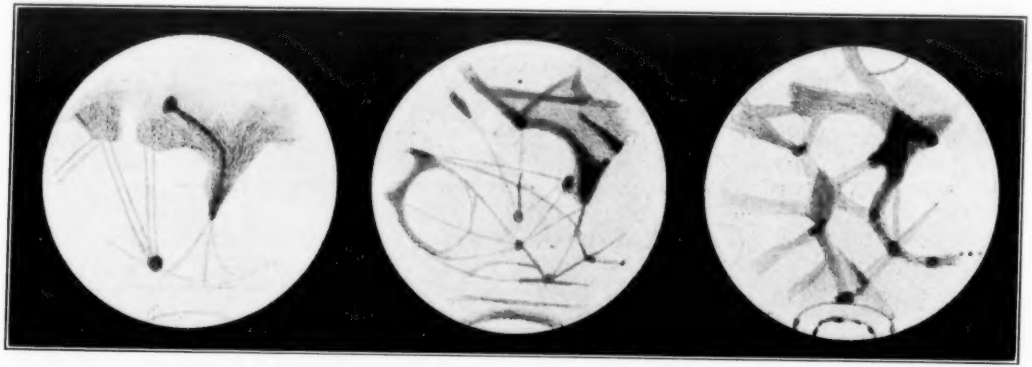
PLATE XXXI



7
1890, May 19
Aug. 23

8
1890, July 17
Oct. 22

9
1894, Oct. 25
Jan. 21



10
1897, Feb. 24
Apr. 27

11
1899, Feb. 28
May 8

12
1901, Jan. 23
May 12

the present instance. For many years the British Nautical Almanac has used the value 4″.68 for the semi-diameter of Mars. This value was fully corroborated at the Lowell Observatory in 1894, Annals **1**, 75, from observations made by all three of the observers, but chiefly by Professor Douglass, and is probably correct to within a little over 0″.01. The American Ephemeris on the other hand uses the value 5″.05, which is certainly wrong, and was deduced many years ago by Peirce. For the next opposition both almanacs use the American computation based on the value 5″.05, for both the diameter and for q, although the British Almanac by an inadvertance repeats on another page from former editions the statement that the value 4″.68 is used. Those observers therefore who have in the past depended for their physical ephemeris on the British Nautical Almanac should notice the change, which will amount in the case of the diameter to over 1″.

In our Reports Nos. 3 and 4 attention was called to the apparent gradual shifting both in latitude and longitude of certain sharply defined points, bays, and promontories upon the surface of the planet. The fact that certain areas were sometimes light and sometimes dark had been known for many years, but that well defined points and lines slowly shifted their positions, rendering accurate mapping impossible, had not been generally recognized. It is not even probable that we can map the surface accurately for a given position of the planet in its orbit, that is, for a given season of its year, as we shall show a little later, for what is correct one year may not be correct the next at the same season.

When an unexpected result depends entirely on the drawings of a single observer, it is always open to the suspicion, at least among others than the observer himself, that his drawings were not very accurate in the first place. When two independent observers reach the same conclusion however, neither having any previous knowledge of the other's investigation, it should carry greater weight. In the present case the two explanations offered for the discrepancy prove to be entirely different.

If we turn to the Observations of Planetary Surfaces made at the Observatories of M. Jarry-Desloges **3**, 237, we shall find that M. G. Fournier made a series of determinations of the positions of 98 points on the planet's surface, during the opposition of 1911. Instead of merely taking the mean position from all the observations of each point, he made a separate determination and map of the location of every point at each of the five different presentations observed. Selecting 20 of these that lay in very different latitudes, and were clearly identified and sharply defined, he found that there was a gradual shifting of the latitudes of these points, so that between the first and the fourth presentation there was a mean shift of nearly 3°.

On investigating the matter the writer found that the shift amounted to 2°.7 ±1°.8. It is doubtful if the latter figure means anything however, since it is probable that some of the latitudes really shifted more than the others. Seventeen of the differences in latitude were negative, two positive, and one zero. That is to say the latitudes shifted on the whole towards the south. M. Fournier ascribes this shift to an error in the adopted inclination of the axis of the planet. Since during the one hundred and twenty days involved, the planet would barely have traversed 60° in its orbit, it is quite impossible that any error in the inclination could be so great as to cause so large a deviation in that interval.

It occurred to the writer that it would be interesting to note if the longitudes also shifted. The four most southern stations were located on lines running nearly east and west, and were therefore not adopted for this investigation. They were consequently rejected. The remaining sixteen were well defined in longitude, and showed a mean increase of 2°.9 ± 1°.9. The shift was slightly greater therefore than that in latitude. Thirteen results were positive, two negative, one zero.

The point showing the greatest shift in both latitude and longitude was, oddly enough, Fastigium Aryn, the point from which all martian longitudes are reckoned, and which we may expect was observed with the greatest care. It shifted 6° in latitude, and 7° in longitude. The five successive determinations of its latitude were −3°, −3°, −6°, −9°, and −4°, of its longitude 357°, 357°, 357°, 4°, and 0°.5. Other points showing a notable shift of position were Astarte Lacus on the northern border of the Mare Cimmerium, which shifted 6° in latitude, Oxia Palus at the northern extremity of Margaritifer Sinus, which shifted 7° in longitude and 4° in latitude, and a point on the northern border of Aurorae Sinus, which shifted 6° in longitude. The eastern end of Mare Sirenum, which is not included among his selected points, but lies in the region where the writer found the greatest change, shifted 4° in latitude and 9° in longitude.

The accuracy of longitude determinations is affected somewhat by uncertainty as to the exact position of the terminator of the planet, so that they are not so accurate as those made in latitude. Opposition occurred during the third presentation. The first and second presentations gave practically identical results, only two latitudes and two longitudes showing any difference. The fourth presentation showed the maximum change in latitude, and the fifth the maximum in longitude 3°.8.

If now instead of dealing with only one opposition, we note the changes that take place upon the planet in a given region during a long series of years, we shall find some of those observed are very marked. In his last Report on Mars, No. 6, the writer stated his belief that it was

to these changes rather than to the shape of the markings themselves, that we should turn in order to obtain information as to the nature and origin of the canals, and light on the question of their possibly artificial character. To facilitate this investigation he has arranged in Plates XXX, XXXI and XXXII what seem to him the best drawings in his collection of one particular region on Mars, and presents them, all drawn on a uniform scale, to the readers of POPULAR ASTRONOMY.

These drawings represent the region between the Syrtis major and the canal Amenthes as it appeared at each of the last eighteen oppositions. In Table I the first four columns give the number and date of the drawing, the name of the observer, and the reference. In this last column Flammarion's great work on Mars has been referred to as far as possible, since some of the original memoirs are now very difficult to obtain. The fifth column gives the aperture of the telescope in inches, and a letter to indicate whether a lens or a mirror was employed. The sixth column gives the heliocentric longitude of Mars, the seventh the corresponding longitude of the sun ☉, and the last the resulting Martian date. In order to avoid giving a preponderance of weight to the style of drawing of any particular individual, the writer has made use of the work of as many different observers as practicable, twelve in all.

Under each drawing is given its number and the terrestrial and Martian dates. The Syrtis major is the prominent and funnel-shaped marking shown in all of the drawings, and particularly conspicuous in number 3.

TABLE 1.

DESCRIPTION OF FIGURES IN PLATES XXX, XXXI AND XXXII.

No.	Date	Observer	Reference	Tel.	H. L.	☉	M.D.
1	1877 Oct. 14	Schiaparelli	Flammarion I 295	8 *l*	7.9	280.1	Dec. 28
2	1879 Oct. 28	Schiaparelli	" I 336	8 *l*	41.8	314.0	Feb. 1
3	1882 Mar. 13	Burton	" I 365	9—	131.0	43.2	May 1
4	1884 Feb. 19	Schiaparelli	" II 5	8 *l*	140.3	52.5	May 12
5	1886 May 21,22	Perrotin	" I 405	30 *l*	200.6	112.8	July 12
6	1888 June 5	Schiaparelli	" II 24	18 *l*	228.8	141.0	Aug. 9
7	1890 May 19	Guillaume	" I 477	8*m*	242.0	154.2	Aug. 23
8	1892 July 17	Pickering	Unpublished	13 *l*	301.6	213.8	Oct. 22
9	1894 Oct. 25	Campbell	Flammarion II 183	36 *l*	30.6	302.8	Jan. 21
10	1897 Feb. 24	Lowell	Annals L.O. II 416	24 *l*	116.1	28.3	Apr. 17
11	1899 Feb. 28	Cerulli	Flammarion II 469	15 *l*	137.1	49.3	May 8
12	1901 Jan. 23	Douglass	Annals L.O. III Sup. 50	24 *l*	140.3	52.5	May 12
13	1903 Apr. 2	Molesworth	Mem. B.A.A. Pl IV	13*m*	189.5	101.7	July 1
14	1905 June 7	Antoniadi	Mem. B.A.A. Pl III	8.5*m*	243.1	155.3	Aug. 24
15	1907 Aug. 2	Jarry-Desloges	Obs. J-D. I 18	11 *l*	300.0	212.2	Oct. 21
16	1909 Oct. 29	Jarry-Desloges	Obs. J-D. II 36	11 *l*	22.5	294.7	Jan. 12
17	1911 Nov. 11	Jarry-Desloges	Obs. J-D. III 36	8.5 *l*	54.7	326.9	Feb. 14
18	1913 Dec. 10	Pickering	Unpublished	11 *l*	92.5	4.7	Mar. 24

The chief reason why some of the drawings of it at first look out of proportion is on account of the inclination of the axis of Mars. Thus in

Figures 1, 8, and 16 the south pole of the planet was inclined towards the earth, while in Figures 4 and 12 the north pole was turned towards us, presenting this region to much better advantage.

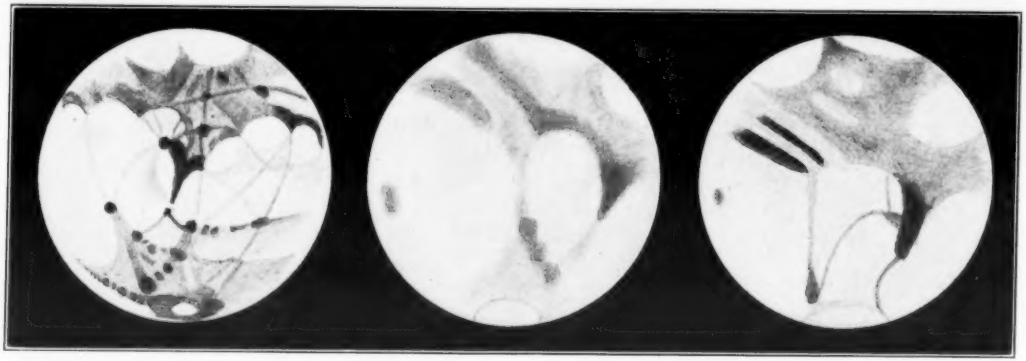
An important question is how far the personality of the observer affects the drawings. The two figures in which the canals are represented the widest are numbers 12 and 14 by Messrs. Douglass and Antoniadi, and these observers usually represent them wider than they appear to most astronomers. In the other cases there is practical unanimity as regards the breadth of the narrower canals shown, except as regards Figure 9 by Professor Campbell, who shows only the Nepenthes. His other markings are not canals properly speaking. In other drawings however he shows the canals as narrow lines, like the other observers.

The most important question of the observer's personality however relates to the proportions and position of the main markings and canals. Here however the writer believes that personality has but little effect, and that the general shape is in all these cases pretty accurately represented. To test this question of general accuracy as well as that of the representation of fine detail, he proposed a year ago that a number of well known observers should make drawings of the planet in six different martian longitudes previously adopted, all the drawings being on the same scale. The drawings were to be forwarded to the Secretary of the British Astronomical Association to be published together in its Memoirs. The writer recently wrote asking what progress was being made in this publication, but, probably owing to the excitement in England at the present time, no answer had as yet been received, and it is feared that some further delay may ensue.

While it is not thought, as far as the fainter markings are concerned, that there is much difference in the eyes of different observers, provided their eyesight is keen, which term doubtless applies to all those whose work is here represented, yet some are probably more willing than others, to record as certain very faint markings that are seen with difficulty. In this paper we shall therefore consider merely the more obvious markings, which all under similar circumstances would be likely to record. A more important difference that we should consider, depends on the seeing. It is probable that Burton, who had a very keen eye, and also Antoniadi would have recorded finer detail had they been located under more favorable atmospheric conditions, that is in a more southern latitude.

The aperture of the telescope appears to have but little influence on the results beyond the fact that we find from the Table that the smallest aperture whose results have been accepted is eight inches. Neither Figures 5 or 9, made with refractors of the largest size, show as fine detail as many of the others made with much smaller apertures. This

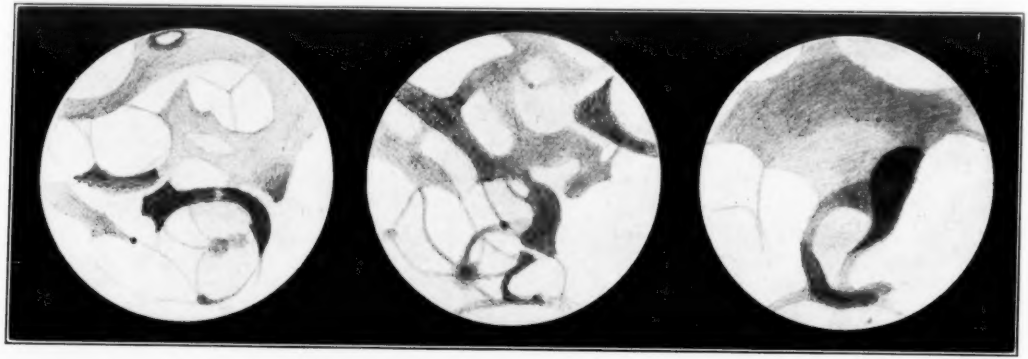
PLATE XXXII



13
1903, Apr. 2
July 1

14
1905, June 7
Aug. 24

15
1907, Aug. 2
Oct. 21



16
1909, Oct. 29
Jan. 12

17
1911, Nov. 11
Feb. 14

18
1913, Dec. 10
Mar. 24

confirms the opinion of several of the more modern observers of Mars, who make it a practice at times of bad seeing to reduce the apertures of their telescopes by means of diaphragms.

With regard to the duplication of the canals, only Schiaparelli, Perrotin and Lowell show it in their drawings. M. Jarry-Desloges writes (Observations **3**, 264,) that both of his assistants saw it independently on the same night, but that he could not see it himself. The writer has seen it clearly in a modified form upon the moon, as stated in the November number of POPULAR ASTRONOMY (The Double Canal in Aristillus). This canal will serve as a standard for comparison with the visibility of any martian doubles observed in the future. Messrs. Douglass, Antoniadi, and the writer have all suspected duplications on Mars, but have not succeeded in convincing themselves as yet that what was seen was an objective reality. As shown in Report No. 5, oppositions occurring near February 7 and June 1 are particularly well adapted for showing it. The next opposition of the planet occurs February 9, 1916, and is therefore an unusually favorable one.

Although the different drawings present a great variety of detail, no two closely resembling one another, save in their general outlines, yet seasonal changes do not seem to be as pronounced on Mars as we should naturally expect. Such changes should be most marked near the poles of the planet, but as these regions are usually very near the limb, the middle latitudes of the temperate zones are the regions most favorably located for our investigation. The bright region of Hellas, in south latitude 40°, shown just above the center of Figure 1 is traversed by a single canal. In Figure 2 it is crossed by two, while in Figure 16 there are three. It seems to be seen to the best advantage during the martian months of December, January, and February, their summer, although also visible in October, Figure 8, when no canals were visible. Near the equator a bright band divides the Syrtis in Figures 1, 2, 9, 11, 16, and 17. These all correspond to martian dates in December, January, and February, their dry season before the floods are released, save Figure 11 which occurs in May.

In the north temperate zone, in latitude 50° we find the Boreosyrtis, the dark horizontal marking near the bottom of Figure 18. We notice that it is visible in Figures 3, 4, 12, 13, 17, and 18. The corresponding martian dates are in February, March and May, but also one in July. Since it is due primarily to the melting of the northern polar cap, it is clear why it is seen mainly in the spring months, but not why it should appear in July. In this latter month, Figure 13, it forms a large area, though hardly visible at all at about the same season in Figures 5 and 6. Moreover it is invisible in Figures 10 and 11, corresponding to April and May, just the months when we should expect it to be conspicuous.

There is another kind of seasonal change, however, that is quite unlike those previously mentioned, in that it pertains to the whole surface of the disk. It is found that between March and August the dark markings and canals lie in a general north and south direction, while between August and March their direction is more or less east and west. Thus compare figures 4, 10, 12, and 13 taken in April, May and July with Figures 1, 8 and 16 taken in October, December, and January. Again, those drawings taken during the summer and winter months show rather more detail than those taken during the spring and autumn.

Thus we may say that while this face of the planet does present seasonal changes, yet they do not always occur. There seem to be many exceptions. Some of them, notably those of Boreosyrtis, might be ascribed to droughts and freshets, and should be especially looked for in the future.

Turning now to what we may call the non-seasonal changes, we may note that the clearly marked lake in the upper part of Figure 10 is shown again in Figure 11, but it will be seen that the northern boundary of the dark region has retreated, and has shifted in latitude at that point through some 15°, or 600 miles, although the season on Mars is only one month later. Figure 10 is corroborated by Figures 7 and 17, Figure 11 by 14 and 15. The bulge in the outline to the right of the Syrtis shown in Figures 8 and 17, is usually replaced by a concavity, see Figures 7 and 9, but has been corroborated in certain photographs of the planet.

One of the most striking changes is the varying breadth of the Syrtis at its northern extremity. Changes in this region were long ago pointed out by Flammarion, Planéte Mars **I**, 575. In Figure 1 the northern extension was narrow. It widened in Figures 2 and 3, was still wide in Figures 4 and 5, then narrowed until Figure 8, and disappeared in Figure 9. It remained narrow until Figure 18, when it again suddenly broadened. It is shown as wide in the drawings of Messrs. Douglass and Antoniadi, Figures 12 and 14, but, as we have already seen, all canals are represented as wide by these observers.

A change of still different character pertains to the canal Thoth. This canal lies in a north and south direction between Amenthes and the Syrtys Major. Amenthes is clearly shown in Figures 3, 14 and perhaps 15, to the left of the Syrtis, It is also shown on the extreme left of Figure 6, the upper portion being single, the middle missing, and the northern end double. Between it and the Syrtis, joining two lakes, lies the Thoth. It is also shown in Figures 2, 12, 13, 15, 16, 17, and 18. The difficulty that sometimes arises in identifying the canals is well illustrated in some of the other drawings. Thus in Figures 4, 5, 7, 10, and 11 a canal is shown occupy-

ing very nearly this same place, but extending further south. Evidently the same canal is represented in these five drawings, but is it the Thoth or the Amenthes? Schiaparelli identifies it in Figure 4 as Thoth; Cerulli in Figure 11 agrees with him. Lowell identifies it in Figure 10 as the Amenthes. It really seems to lie between the two, as they were named and represented by Schiaparelli, see Figure 6. Compare also with Figures 2 and 3 where the region is central. The following observers agree as to the position of Amenthes:—Burton, Schiaparelli, Antoniadi, and Jarry-Desloges. The following agree as to Thoth:—Schiaparelli, Douglass, Molesworth, Jarry-Desloges, and Pickering. The following agree as to the location of the intermediate canal:—Schiaparelli, Perrotin, Guillaume, Lowell and Cerulli.

It is likely that the last five observers, who agree so well with one another, could all have made the same mistake in wrongly locating this canal? If they have, what shall we call it Thoth or Amenthes? If they were not mistaken, is the canal a new one replacing the two others? In that case should it have a new name? Should we for instance follow the precepts of the lamented Lewis Carroll, and call it the Thamenthes? Finally has one of the original canals merely shifted its position? If that is the case the fact is clearly a matter of some importance, since it may dislocate our whole system of nomenclature, and be the cause of endless confusion. In our Report No. 6 evidence was presented that the canals encircling Elysium were subject to a gradual shift of position, and it is the writer's opinion that this is the true explanation of the phenomenon here recorded.

Thoth exhibits still another change that clearly is not seasonal. While a canal has existed in this immediate vicinity for a great number of years, yet in all the earlier drawings it has been a faint and apparently insignificant object. In 1911 however, Figure 17, it became much more pronounced, while in the last figure it is shown as one of the four most conspicuous canals visible upon the disk, the others being Sabaeus, Cerberus, and the northern prolongation of the Syrtis. A similar change has taken place in Cerberus, and also, as these figures show, in the Syrtis itself. We might imagine some slow growing form of vegetation like our trees or shrubs gradually establishing itself there, and then, judging by the case of the Syrtis, even more gradually dying out again. It will be interesting to watch for its appearance at the next opposition.

Measures of Thoth taken from Figure 18, and from other drawings made during the past year give it a length of 2000 miles, and a width of about 150.

The contemplative reader before adopting any theory of the martian changes, may well ask himself the following questions. (*a*) Is it possible to offer a probable explanation of this change without calling in the aid

of a martian vegetation? (*b*) If not, can a change on such a large scale have taken place without the aid of some directing intelligence? (*c*) Do such conspicuous non-seasonal changes occur at the present time upon earth, or did they before the advent of civilized man, for instance in North or South America.

It is obvious that if we were to cut down an extensive forest, or were to plant certain dark colored vegetation on lighter colored plains, we could now produce just such a change in the appearance of our planet, if it were desirable to procure food in this manner, or for any other reason. That is an easy explanation to offer, but can we find an equally plausible one that avoids the necessity of assuming a martian intelligence?

In the Monthly Report on Mars No. 6, three hypotheses were given involving martian intelligence, and were designated as (*a*), (*b*) and (*c*).

Two others requiring vegetation but not intelligence were also given, one depending on volcanic activity, and the other on a change in meteorological conditions, notably the moisture bringing winds. These may be designated respectively as (*d*) and (*e*). To make this list complete, and include every hypothesis of which the writer is aware, that is not obviously impossible, we should mention here the ice floe theory of M. Baumann. This theory which we will call (*f*) requires neither vegetation nor intelligence, and is perhaps the most plausible of all those which do not demand the existence of the latter upon the planet. He suggests that the so-called seas are continents, the lakes are islands, and the desert regions ice floes, colored by volcanic deposits,—and perhaps vegetation. Where the ice floes crack showing the water beneath them we have the canals. There are obvious objections to this theory, which he deals with in great detail*, but overlooking these, or accepting his explanations, it certainly has its merits for the consideration of those who decline to recognize any theory which involves the existence of intelligent life, outside of our own world.

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* Der Planet Mars. A. Baumann.

A METHOD OF CONSTRUCTING A VERNIER FOR A SMALL EQUATORIAL.

GILBERT LANHAM.

While in this town during the months of July and August, the writer had at his disposal a 4-inch Brashear, equatorial refractor. At the suggestion of my friend, who is the owner of the instrument, it became my task, during spare time, to adjust the polar axis, and so to put the same in order. Most small telescopes are not meant for any serious purpose,—for it is evident that neither of their position circles intended them for such; although, when it comes to the economical advantages of the equatorial for non-portable purposes, circles of reasonable fineness ought to form an essential part.

MR. FERRYMAN'S OBSERVATORY.

In the case of the instrument just mentioned, the declination circle is divided to single degrees, and the R.A. circle is divided to 5 minutes. Among its accessory eye-pieces, the lowest is 43, and has a field 50′ in diameter. Using this in searching for a faint object, a comet for example, an observer may easily run the chances of failing to find the same by reading the circles to single degrees and fives of minutes, or by doubtful estimations to ¼ degree and to one minute with the non-mechanical eye; and, moreover, when it comes to taking the position of

an object by the reliable differential method, even this cannot be done with any degree of accuracy. With atmospheric refraction uncorrected, search is made difficult. Again, at the suggestion of the owner to devise a more accurate method of making readings (by vernier if possible) on his instrument, I set about with the belief that this was the most practical appliance that could be used, considering the coarseness of both position circles. Consequently, the purpose of this article is to give an account of the method used to obtain results accurate to a reasonable amount.

In looking for an instrument analogous to a dividing engine for spacing a vernier, one may resort to a worm-wheel and worm, and to a slow motion attachment, both of which can be found complete on an equatorial telescope. Asmall disc, from 1 to 4 inches in radius, made of tin or some other thin metal, served as the measuring apparatus; this was attached concentrically and at right angles to the end of the worm-axle for moving the telescope in R. A. A diameter scratched upon the disc, and an index arm placed in proper position, completed the apparatus necessary for dividing the vernier for this ordinate. The other vernier was divided by means of a similar disc fastened in the same manner to the head of a screw for slow motion in declination. Since this particular screw required a little less than nine revolutions to turn the declination circle through one degree, practically no correction was necessary, because of the fact that the clamp in this ordinate has an arm about 20 in. long on which, at its extremity, the screw lends its function. If this arm were comparatively short and likewise operated by a screw, then a proper correction would be required,—for the sine and tangent (to which the screw corresponds) of an angle, like the other "trig" functions, are not proportional to the magnitude of the angle. But if the same portion of the screw is used throughout the whole operation, a correction is not important.

If we let

D = value of 1 division of the circle in terms of rotation in arc of the disc,

D' = value of 1 division of the vernier in terms of rotation in arc of the disc,

i = any integral number,

f = a fraction of a rotation in arc,

v (arbitrary) = number of divisions which the vernier is to have,

c = number of divisions on the circle that are equal (in arc) to the vernier,

then,

$$\frac{c}{v}\,(i \times 360^\circ + f) = D' \qquad (1)$$

It now remains to determine the value of f. This may be done in either of two ways: (1) directly by means of a protractor, or (2) by computation. By this method,

$$\sin \tfrac{1}{2} f = \frac{k}{2r}$$

where k and r are the semi-chord of (arc) f and the radius of the disk, respectively. I might add here that it is very convenient to use the metric system and a pair of small dividers in making linear measurements, or else a micrometer caliper of proper form, based upon the same system. From a table of natural values of the trigonometric functions, the value of f, depending upon correct measurement, can actually be obtained within two or three minutes.

Now

$$(i \times 360°) + f = D. \qquad (2)$$

Having now found D, and substituting this in (1) for the first member of (2) above, we have

$$\frac{c}{v} \times D = D'.$$

Since v is to be chosen, it is important that this should not be more than 10; it may conveniently be 3, 4, 5, 6, 8, or 10. If 20, 30, or 60, and if the vernier be constructed by the present method, large division errors are too apt to render all results worthless. In laying off on the disk D', either of the two ways as mentioned above may be employed. By the latter,

$$D' - (i' \times 360°) = f'$$

$$2 \sin \tfrac{1}{2} f' = k',$$

Now since k' is the chord of f', it can be laid off on the disc in both directions from the index radius (which was drawn at first). Should D' be less than 360°, then i' in the above equation is equal to zero, as is likewise the case in (1) and (2).

After replacing the disc on the worm axle or slow motion screw, as the case might be, the "dividing engine" is completed. Frequently both index arms of a small equatorial have at their terminations a plate containing a single index line that can nicely be used as a first line of the vernier. If none has been provided in the first place, then it is a mechanical problem to supply a suitable one. For the declination circle a double vernier was required for reading in both directions, this, of course, being composed of two direct-reading verniers having in common the same index line as a zero point. The R.A., circle, having the hours numbered in the same direction as the earth's motion, required a single direct-reading vernier, this serving the purpose for any position of the instrument's optical axis in the latter ordinate.

The operation of dividing a vernier by this method is as follows: Bring into coincidence a division line on the circle with the index-line on the vernier plate, then clamp the telescope for the ordinate corresponding to that for which the vernier is to be divided (in case it is the declination vernier, the slow motion clamp should be depended upon). After bringing the index line on the disc to its index arm that was provided for the purpose, carefully rotate the disk through an arc measured off between these two points equal to D' as computed according to the formulas above. A division on the circle has now been carried in the direction in which the movement has taken place, to a point from the index line where a division line on the vernier-plate is to be ruled. The space between these two lines on the plate will be found to equal $\frac{c}{v}$ times a division on the circle. All division lines may at first be ruled with a needle point and a beveled straight-edge, or, say, with the edge of a safety razor blade. Ruling half of the lines from the index line, and then the remainder of them backward from the last on the same vernier, will reduce any certain division errors to a minimum. When the needle-scratched lines are made, more than half of the difficulty is past; what remains is to deepen the scratches after taking off the plate, with the same tools plus a few heavier needles and a very sharp pointed pen-knife, all used under a magnifying glass, being sure to enlarge the lines to about the same width as those on the circle itself. The lines on the vernier need not be longer than one-eighth of an inch. In my results there are no errors of division greater than $\frac{1}{300}$ of an inch. Although this is a large error, it is due, nevertheless, to coarseness of the division lines on either circle and to the necessity for those on the vernier to be as coarse, — $\frac{1}{120}$ of an inch in width. Taking the declination circle, for example, which is close to six inches in diameter and read, like the R. A. circle with a six-division vernier, one degree at its circumference equals nearly $\frac{1}{16}$ of an inch, and a minute, roughly $\frac{1}{900}$ of an inch: therefore, since each division subtends an angle of 7′ or 8′, it is easily possible for an error of 3′, at most, to be introduced as a result of the factors mentioned above. If great pains are taken in dividing the vernier and in enlarging the needle scratches, results can be had which may reasonably suffice for a small equatorial.

Wenatchee, Wash.,
Aug. 31, 1914.

AMERICAN ASTRONOMICAL SOCIETY.

REPORT OF THE SEVENTEENTH MEETING.

[*Continued from page 570.*]

PHOTO-ELECTRIC PHOTOMETRY OF STARS.

By Jacob Kunz, W. F. Schulz, and Joel Stebbins.

Experiments have been carried on in the making and testing of sodium, potassium, rubidium, and caesium cells. The dark current has been greatly decreased by a platinum guard ring fused through the glass, the small remaining current being easily compensated. Attached to the 12-inch refractor, a photo-electric cell and string electrometer have given satisfactory results, and the apparatus is already more sensitive than the selenium photometer. The chief advantages of the photo-electric cell over selenium are the rapid recovery from light effect and the general freedom from irregular disturbances.

Observations of the eclipsing variable α *Corona Borealis* with the new photometer confirm the previous results with selenium, and indicate that this star has a variation of about 0.12 magnitude, and the duration of the minimum is only $\frac{1}{25}$ of the period.

ON THE PROPER MOTION OF THE VIRGO NEBULA, N.G.C. 4594.

By C. O. Lampland.

The high radial velocities observed by Slipher for a number of nebulae suggested that observations of these objects for proper motion and parallax might give results of value. It was accordingly planned last year to make a series of negatives with the 40-inch Lowell reflector, and extending over a period of years, of some of these nebulae, with the object of making measurements for proper motion. At that time negatives of short exposure were made of the dark-lane nebula in Virgo, N.G.C. 4594, and additional observations of it were obtained again this year. One of the negatives of this nebula, exposed June 16 of the present year, has been measured and reduced. The measurements were made with a Zeiss comparator, and Turner's six-constant method

was used in the reduction. The constants of the plate were determined by the method of least squares from seven AG (Cambridge) stars. The position of the nebula was found to be as follows:

$$\left.\begin{array}{l}\text{R. A.} = 12^{h}\ 35^{m}\ 31^{s}.39 \\ \text{Decl.} = -11^{\circ}\ 9'\ 3''.4\end{array}\right\} 1914.0$$

While the primary object in view in these observations was the most accurate determination of position, for subsequent use in investigations on proper motion, it was thought worth while at the present time to search for measurements by earlier observers. Eleven positions, with epochs of observation extending back to 1861, were found and a preliminary solution for proper motion was undertaken. Data for assistance in the assignment of weights and the application of possible systematic corrections to the different determinations were not available. Several solutions were carried through in which the weights were changed sufficiently, it is thought, to show whether or not the resulting values have a real existence. For none of the solutions does a change of sign occur and the considerable variations in the combination of the observational material give quite concordant results, which would appear to indicate that the observed values of the coördinates have a persistent trend. It seems highly probable that we have in the present case found genuine proper motion for a nebula. The motion indicated is of the order $+0^{s}.006$ in R.A. and $-0''.05$ in Declination.

Since these preliminary solutions were made, a further examination of the literature on measurements of nebulae has brought to light several additional determinations of position, and one more negative with the 40-inch reflector has been measured. A more thorough treatment of all the observational data is in progress and the results will be published in a forthcoming number of the Lowell Observatory Bulletin.

THE SYSTEM MIMAS-TETHYS, SATELLITES OF SATURN.

By Kurt Laves.

The system of satellites Mimas-Tethys has nearly commensurable motions of type ½. It is at such a distance from Saturn that the arithmetic mean of the recessions of the nodes due to the oblateness of the central body very nearly equals the angle of elongation. In consequence of this the satellites create in each other's motions perturbations of the first order, of a librational character. The fact that both Mimas and Tethys have appreciable inclinations, while the other inner satellites have none, appears to be due in part to this librational perturbation in inclination. Newcomb's theorem concerning the impressed

eccentricities of a pair of commensurable satellites circulating about an ellipsoidal central body finds in a modified way its counterpart in the following theorem:

If under the circumstances mentioned above the satellites have very small inclinations, they will increase them by their mutual perturbations, which will be the stronger the larger their masses and the nearer are fulfilled the twofold conditions of commensurability of their mean motions, and the commensurability of the mean motion of their point of elongation and that of the point half way between the ascending nodes of the two satellites on the equator of the primary body (Saturn).

Either the perturbative action of Titan or the Sun may be considered in the case of Mimas-Tethys as the cause for the *initial* small inclinations.

MIMAS AND ENCELADUS.

By Percival Lowell.

Observations by Mr. E. C. Slipher and the writer on the brilliancy of Mimas and Enceladus in December 1913, and January, February, and March 1914, resulted in revealing that these two satellites of Saturn are of very unequal albedo in different parts of their apparent orbits, and that the said variations recur *in situ*, showing that the satellites turn always the same face to their primary. Thus their revolutions and their axial rotations are synchronous.

Not only were the differences in brightness in both these satellites marked, but they were greater than in any of the other Saturnian moons—Japetus alone excepted. In the case of Mimas the variation amounted to 0.43 magnitude; in that of Enceladus to 0.33 magnitude. Both moons appear brightest near their western elongations and faintest near eastern. Their magnitudes and range are:

Mimas	12.90 to 13.33
Enceladus	12.33 to 12.67

Both bodies are too small to show a disk, their size being inferred from their relative brilliancy to Tethys.

Since an increase of one magnitude corresponds to 2.5 the original illumination, one-half a magnitude means 1.6 as much light and one-fourth magnitude corresponds to 1.25 as much. A difference of one-half and one-third magnitude in these airless bodies is therefore just such a change as the character of the rock surface would cause.

This detection adds two more to the number of bodies we know to turn always the same face to the one whose retinue they form, observant alike of association and regard. It is of interest cosmically that all the satellites, sufficiently studied so far to give evidence on the point, agree in following this rule.

STELLAR PARALLAX RESULTS FROM THE SPROUL OBSERVATORY.

By John A. Miller.

The twenty-four inch refracting telescope of the Sproul Observatory of Swarthmore college, is used almost exclusively for the determination of stellar parallax. The method adopted is practically that described by Schlesinger in the *Astronomical Journal*, Volume 32 to 34.

The parallaxes determined for nine stars are as follows:

Star	α 1900		π	
	h	m	″	″
Lalande 13, 198-200	6	45	0.015	± 0.008
Nova Geminorum	6	48	—0.019	± 0.014
Bradley 1433	10	16	0.080	± 0.008
Lalande 21, 185	10	58	0.433	± 0.010
33 Virginis	12	41	—0.003	± 0.008
ζ Herculis	16	37	0.086	± 0.004
61 Cygni	21	02	0.301	± 0.010
Bradley 3077	23	08	0.167	± 0.027

(Read at the conversazione.)

LONGITUDE BY WIRELESS.

By D. W Morehouse.

(Paper read but no abstract submitted.)

THE USE OF PARALLEL WIRE GRATINGS IN PHOTOGRAPHIC PHOTOMETRY.

By J. A. Parkhurst and H. L. Alden.

For the establishment of an absolute photometric scale on plates taken in focus, many methods have been suggested and several of them tried at the Yerkes Observatory. The best method seems to be to avoid the assumptions necessary in the case of successive exposures and to depend on the difference in magnitude between the central image and the first-order spectra, on plates taken through a parallel wire grating placed over the objective. This difference can be calculated from the ratio of free space to wire diameter, and checked by laboratory measures and exposures on stars of known magnitude.

The practical problems treated were:—

(1) To choose the proper ratio and pitch in order to get images the right distance apart, with the most favorable difference of magnitude, and sufficiently well defined to permit of precise measurement. This was done for the 6-inch camera, the 2-foot reflector, and the 40-inch refractor.

(2) To calibrate the gratings to find the most accurate value possible for the difference in magnitude between the central image and the spectra. This was done by (a) the aid of an auxiliary "normal grating,"

i.e. one whose free space and wire are equal, thus presenting the most favorable conditions for calibration; and (b) by direct measures of the absorption of the gratings on a Ferguson bar photometer.

VISUAL AND PHOTOGRAPHIC MAGNITUDES OF STARS IN THE NORTH POLAR SEQUENCE.

By J. A. Parkhurst and H. L. Alden.

(1) The visual magnitudes were measured with the "equalizing-wedge photometer" described by Parkhurst in Vol. 13 of the *Astrophysical Journal*. The wedge was calibrated anew for this work by three independent methods, the concordant results of which left uncertainties not greater than 0.03 magnitude. The magnitudes were based on the Yerkes Actinometry, and had probable errors of about ± 0.02 for all except a few of the faintest stars. The measured stars ranged from 6.46 to 14.46 magnitudes. Comparison with H. C. 170 shows a systematic difference in scale so that the Y. O. magnitude numbers are 1.5 less than the H. C. at magnitude 13. Comparison with Seares' photo-visual magnitudes shows a difference in zero point rather than scale. The Y. O. values agree with the theoretical limit of visibility of the Yerkes 40-inch and the Dearborn 18½-inch.

(2) The photographic magnitudes were obtained with the 6-inch camera and the 2-foot reflector on plates taken with the gratings described in the preceding abstract. The results were based on the magnitudes of the Yerkes Actinometry. Excepting a few of the faintest stars the probable errors of the means of 19 plates were about ± 0.02.

(3) The "color-index", the difference between the photographic and visual magnitudes, shows a systematic increase as one passes to the fainter stars, so that at magnitude 16 the minimum value of the color-index is 2.0. The corresponding minimum as found by Seares, from photographic and photo-visual plates, was 0.5. The remaining difference, 1.5 magnitude, therefore seems to be physiological, due to the Purkinje effect, combined with the increasing redness of the faint stars, which has lately been shown to exist by several authorities.

THE SPECTRUM OF THE CLUSTER-TYPE VARIABLE RS BOÖTIS.

By F. G. Pease.

Eleven photographs of the spectrum of *RS Bootis* (maximum about 9.2 magnitude) made on July 20-23, 1914, with exposure times ranging from 30^m to 105^m, reveal a variation in type which coincides with the variation in light. At maximum the spectrum is B8, at minimum F0. The spectra are typical, as far as can be judged from the small scale plates.

LIMITING MAGNITUDES OF STELLAR CATALOGUES.

By E. C. Pickering.

Numerous extensive catalogues of stars are now being prepared which are intended to include all stars brighter than a given magnitude. While it is difficult, if not impossible, to determine this limiting magnitude, it will be convenient to have some standard scale by which different catalogues may be compared. It is proposed to define the limiting magnitude as that for which the number of omitted brighter stars is equal to the number of included fainter stars; in other words, the magnitude such that if all errors could be corrected, the number of stars would be unchanged. For brighter stars, the formula $\log N = 0.52\,M + b$, nearly represents the number N, of stars brighter than the magnitude M. The coefficient of M becomes 0.50 for 6.0 magnitude, 0.40 for 10.4, and 0.30 for 13.3 magnitude. The term b varies with the part of the sky and its area. The relation of log N to M for the whole sky is given in *Harvard Annals* **48**, 178. If we plot this curve and then a similar curve for the given catalogue, we shall find that for the brighter stars they will differ by a constant amount. Applying this correction, the magnitude corresponding to the logarithm of the total number of stars in the catalogue will give the required limiting magnitude.

MEASUREMENT OF CLOSE DOUBLE STARS WITH A SMALL TELESCOPE.

By W. H. Pickering.

By close double stars are meant stars whose distance apart is less than half a second, and by a small telescope is meant one of less than twelve inches aperture. It is impossible to measure such stars by means of a micrometer with an instrument of this size. The writer undertook to measure them by means of his Scale of Ellipticities, that is in regular use in connection with his measures of the varying ellipticity of the disks of Jupiter's satellites. By using various apertures from 3 to 11 inches it was found possible to measure any bright double the distance of whose components lay between 1″.2 and 0″.2.

Five stars were selected from Burnham's Catalogue, each star being measured on three different nights. Of three of these the true distances could only be surmised by extrapolation after an interval of about ten years. Professor Aitken kindly offered to measure them. The others moved in well determined orbits, and their true distances could therefore be computed. These stars were ζ *Sagittarii* 225° 0″.40 computed, 221° 0″.444 observed; β *Delphini* 268° 0.″25 computed,

276° 0.″249 observed. While good seeing is necessary to measure stars of this character, the writer believes that with small apertures of from 3 to 5 inches it would frequently be possible, even in the north, where the seeing is comparatively poor, to obtain good results.

THE SOLAR ROTATION IN 1913.

By H. H. Plaskett.

The plates on which this discussion is based were taken in June 1913 and were measured and reduced in the summer of 1914. The values of the solar rotation obtained may be represented by formulae of the Faye form:

$$\text{Linear Velocity } V = (1.978 - 0.537 \sin^2\phi) \cos\phi$$
$$\text{Angular Velocity } \xi = 14°.04 - 3°.81 \sin^2\phi.$$

These values are nearly four hundredths of a kilometer lower than those obtained by J. S. Plaskett from the 1911 and 1912 plates although his measures of the equatorial region of these plates were practically identical with mine. This fall in values may be accounted for in three ways.

(a) Variation in the Solar Rotation—It was found that the values obtained by previous observers might be grouped into a seven-year period with minima in 1899, 1906, and 1913. This was regarded, however, in the light of further evidence, as decidedly uncertain.

(b) Instrumental errors—It seems possible from the work of Plaskett and DeLury, that some instrumental error of a systematic character may have contributed to the decrease in value.

(c) Personal errors of measurement—A pronounced psychological effect in these differential measurements has previously been found and it is possible that this may explain part of the difference.

The conclusion reached was, that from all view points, it seemed most likely that the fall in values was principally due to instrumental errors.

THE SOLAR ROTATION IN 1912.

By J. S. Plaskett.

The spectroscopic determination of the solar rotation during the summer of 1912 resulted in the following values of the Faye constants:

$$\text{Linear Velocity } V = (2.001 - 0.554 \sin^2\phi) \cos\phi \text{ at } \lambda\ 5600$$
$$\text{“ “ } V = (2.022 - 0.512 \sin^2\phi) \cos\phi \text{ at } \lambda\ 4250$$
$$\text{“ “ } V = (2.012 - 0.535 \sin^2\phi) \cos\phi \text{ mean both regions}$$
$$\text{“ “ } V = (2.012 - 0.531 \sin^2\phi) \cos\phi \text{ mean 1911 and 1912.}$$

while the corresponding angular velocities are represented by the formulae:

Angular Velocity $\xi = 14°.20 - 3°.93 \sin^2\phi$ at λ 5600
" " $\xi = 14\ .35 - 3\ .63 \sin^2\phi$ at λ 4250
" " $\xi = 14\ .28 - 3\ .80 \sin^2\phi$ mean both regions
" " $\xi = 14\ .28 - 3\ .77 \sin^2\phi$ mean 1911 and 1912.

As may be inferred from the mean values above, the determinations of the velocity in 1912 are in very close agreement, within less than one half of one per cent, with those in 1911.

The personal differences of measurement between the writer and DeLury still persist, though with somewhat diminished magnitude, the mean difference being 0.015 km at λ 5600 and 0.035 km at λ 4250 in 1912 as compared with about 0.040 in 1911.

A discussion of the residuals for lines of different elements or different lines of the same element showed that in no case did the mean algebraic residual approach one-half of the numerical residual and that no differences occur which are not readily accounted for by accidental errors of setting.

So far as the observations of the solar rotation at Ottawa during 1911 and 1912 are concerned, there is no evidence of variation in the rate of the Sun's rotation.

NEW ELEMENTS OF MARS.

By Frank E. Ross.

In December 1912, the office of the *Nautical Almanac* undertook a rediscussion of the observations of the planet Mars. The director, Professor W. S. Eichelberger, placed the work in charge of the writer.

Observations of this planet since 1902, or the year in which Newcomb's Tables of Mars were first used in the Ephemerides, showed little if any improvement of Newcomb's Tables of this planet over the Tables of Leverrier which are still in use in the Connaissance des Temps. A slide exhibited the residual errors of Newcomb's Tables at the normal dates nearest opposition, for as many years as are at present available. These residuals are generally based on from 2 to 4 observations. There is a well defined periodicity of the residuals in right ascension shown in the table, having a period of about seventeen years, or the period in which close oppositions recur. It is not a difficult matter to show that the eccentricity of the orbit used in the tables is the element at fault and that a correction of about $+1''$ for the epoch 1900, combined with a small secular term in the eccentricity, will nearly eliminate the residuals. The eccentricity of Leverrier's Tables is greater by $0''.6$ in 1900 than Newcomb's, so that it is in error by only $0''.4$. But Leverrier's secular variation of the eccentricity is greater than Newcomb's by $1''.0$, so that an error of the eccentricity is to be considered

one of the principal errors of both sets of Tables. There are other serious errors in Leverrier's Tables, including errors in mean longitude, and erroneous periodic terms due to a faulty mass of the Earth, which is 7.5 per cent less than the mass of the Earth adopted by Newcomb. The heliocentric mean longitude of Leverrier's Tables, including long period terms, is greater by 1″.8 than Newcomb's for the epoch 1915. It should be stated that with the exception of the long period terms, there are no important differences between the theories of Leverrier and Newcomb.

It is the intention in the present discussion to determine the secular variation of the elements from the observations themselves. The secular variations adopted by Newcomb in his tables of all four of the inner planets were computed not in accordance with Newton's law of gravitation, but by a modified formula in which the exponent 2 is replaced by 2.0000001612. This variation of the law affects only the perihelia. In view of the present unsatisfactory state of the theory of the secular variations of the elements of the four inner planets, I believe that the observed and not the theoretical values should be adopted in tables of their motions.

An important result to be obtained from the discussion will be a determination of the mass of Venus of great weight. There is at present considerable uncertainty as to even its approximate value. The value adopted by Newcomb is 2 per cent smaller than Leverrier's. From a discussion of the recent Greenwich observations of the sun, Cowell finds for the mass of Venus a value a trifle larger than Leverrier's, and 2¼ per cent greater than Newcomb's. The present discussion should give its value with a probable error not far from one part in a thousand.

A SHORT METHOD FOR DETERMINING THE ORBIT OF A SPECTROSCOPIC BINARY.

By Henry Norris Russell.

If ρ is the radial velocity of a spectroscopic binary, v the true, and M the mean anomaly in its orbit, the fundamental equations may be written with the usual notation,

$$M = n\,(t - T) = nT - M_0.$$

$$\rho = \gamma + Ke\cos\omega + K\cos(v + \omega) = G + K\cos(v + \omega).$$

The maximum and minimum velocities, $G + K$ and $G - K$, may be read from a plotted curve, and the values of $M + M_0$ and $v + \omega$ can then be found for each observation. By plotting $v + \omega - (M + M_0)$ against $M + M_0$, we obtain a curve whose form depends only upon the eccentricity of the orbit, while its position in the two coördinates

depends upon the location of the periastron in time and space. Standard curves, of the theoretical form, may be drawn on tracing cloth, and fitted to the points derived from observation, when the principal elements may be read off at once.

This method is applicable to orbits of any eccentricity, and practical tests on selected difficult cases have shown that it is very rapid. By making a second approximation, results practically identical with those of a least squares solution can be obtained with an average of less than two hours work, including all plotting.

(To be published in full in the *Astrophysical Journal.*)

ON THE LENGTHENING OF THE PERIODS OF BINARIES BY TIDAL EVOLUTION.

By Henry Norris Russell.

Moulton and the writer have shown from Darwin's equations that, if the components of a binary system are comparable in mass, the period can never be very greatly increased by tidal action. The present paper contains a numerical computation of the maximum effect of tidal action upon those visual binaries and eclipsing variables whose elements are well determined, assuming for all unknown or uncertain factors the most favorable values which are at all plausible.

It is found that no visual binary whose orbit has been computed can ever have had a period shorter than one year. Arranging the stars in the order of their present periods, in groups of five, it is found that the ratio of the mean minimum initial period to the present period ranges only from 0.25 to 0.17 among eleven groups. A ten-fold increase of the period is possible only for one star in ten.

In the case of the eclipsing variables, when the sizes of the stars are known, it is possible to follow the course of tidal action both forward and backward. Forming twelve groups, in order of period, the average ratio of the initial to the present period comes out 0.43, and that of the final to the present period 1.50 (if the final orbit is assumed circular). The ratios for the individual groups range from 0.32 to 0.64 in the first case, and from 1.17 to 2.23 in the second. These systems, which are probably representative of spectroscopic binaries in general, are therefore, on the average, already fully half way advanced in the course of tidal evolution, and their periods are not likely to be much more than doubled in the future, even if their orbits become considerably eccentric.

These numerical results illustrate the conclusion which had already been demonstrated in analytical fashion—that visual binaries, with periods measured in years, and spectroscopic binaries, with periods measured in days or weeks, do not and can not represent successive stages in the evolution of one and the same system.

ON THE SUSPECTED VARIABLE Y AQUILAE.

By Henry Norris Russell.

The star *18 Aquilae*, ($19^h\ 2^m$, $+\ 10°\ 55'$) was announced as variable by Chandler in 1894, with a period of 4.986 days and a range from $5^m.3$ to $5^m.7$. Photometric observations by Müller and Kempf, Pickering and Wendell disproved the existence of variation of this period, and showed that the range of variation, if any, must be small. The star was found to be a spectroscopic binary at the Yerkes Observatory in 1903, and an orbit, based on 101 plates, taken at the Allegheny Observatory, has recently been published by Jordan. The period 1.30226 days, and spectrum B8, suggests the possibility of eclipses, and the Harvard observations have been reduced with the new period. There are 80 measures by Pickering with the meridian photometer (of which two are very discordant and have been rejected, and 30 by Wendell with the polarizing photometer—all made in 1897 and 1898. Though this is ten years earlier than the first Allegheny observations, the spectroscopic period (whose probable error Jordan estimates at $\pm\ 1^s.3$) is accurate enough to permit a transference of the computed time of eclipse with a probable error of about an hour. All Wendell's observations fall far from the computed times of eclipse, but Pickering's show distinct evidence of a minimum of about $0^m.25$ in depth, coming approximately $0^d.09$ earlier than the computed time. This demands an increase of the period by $2^s.7$, which is not inconsistent with the spectroscopic data. Of 9 observations which show the star to be fainter than normal by $0^m.18$ or more, 8 fall within $0^d.10$ of the times of minimum computed with this new period. It seems therefore almost certain that this star is an eclipsing variable of small range. A study of its light curve is planned at Princeton.

ON THE DISTRIBUTION OF ECLIPSING VARIABLES IN SPACE.

By Henry Norris Russell and Harlow Shapley.

When the elements of an eclipsing variable system have been determined from the photometric data, its parallax may be estimated by assuming that the mass and surface brightness of the principal component have the average values for stars of similar spectral type. It appears probable from existing data that, in the large majority of cases, the estimates so obtained will be within fifty per cent of the truth.

Hypothetical parallaxes have been derived in this way for 90 eclipsing systems. The four largest values are $0''.030$ for *β Aurigae*, $0''.026$ for *β Persei*, $0''.020$ for *W Ursae Majoris*, and $0''.018$ for *R Canis Majoris*. None of the others exceeds $0''.01$.

If there is no absorption of light in space, several of these systems must be more than 5000 light-years distant, and the average distance of the ninety is 2500 light-years. They are strongly condensed towards the galactic plane, their average distance from a plane drawn through the Sun parallel to the galactic equator being 440 light-years. When allowance is made for the observational preference for northern stars, it appears that the Sun is about 60 light years north of the median plane.

The similar calculations of Hertzsprung for the Cepheid variables indicate an average distance (if space is transparent) of 4100 light-years, a median plane 120 light-years south of the Sun, and an average distance from this plane of only 260 light-years.

The assumption of a moderate absorption of light in space greatly diminishes the extreme computed distances. For example, an absorption of $0^m.019$ in 32.6 light-years, (the value recently found by King), would reduce the average distance of the eclipsing variables to 1350 light-years, and the mean distance from the galactic plane to 280, while the corresponding quantities for the Cepheid variables become 2000 and 150 light years. Even so, the estimated distances of some of the stars of each class exceed 4000 light-years. It is worthy of notice that, if space is assumed transparent, the average distance of the stars of both classes from the galactic plane increases with increasing distance from the Sun, and that the introduction of the assumed absorption removes this apparent anomaly.

In any case, it appears that our "Universe" of stars must be at least six or seven thousand light-years in diameter, while few of its members lie more than 1000 light-years from its median plane. Near the galactic poles the stars thin out very greatly at distances well within the space-penetrating power of small telescopes; but there is no evidence that this is true in the Milky Way.

THE DISTRIBUTION OF THE ELEMENTS IN THE SOLAR ATMOSPHERE FROM ECLIPSE RESULTS.

By Charles E. St. John.

The distribution of the elements deduced from the radial displacements of the Fraunhofer lines in the penumbrae of eccentrically located sun-spots, by interpreting the displacements as a Doppler effect varying with level, is confirmed by the extensive data of the 1905 eclipse published by Mitchell. In both cases the resulting distribution shows that the H and K lines of calcium are the lines of highest level, followed by hydrogen, and that in the main the heavy and rare elements occur only in the lower portions of the reversing layer, none of their lines reaching a height of 500 km except they are enhanced.

To be continued.

HOW TO FIND THE CONSTELLATIONS.

MARY H. DUNOVANT, SARAH L. MAYES AND SARAH W. WEINGES.

[*Continued from page 582.*]

Aquila (The Eagle) and Delphinus (The Dolphin.)

Just across the Milky Way from Vega in the Harp, lies a row of three stars; a very bright one in the middle called Altair, and two of scarcely less brightness lying one on each side, at a distance of about two degrees from Altair. Altair is in the neck of the eagle and a row of four stars just north-west of Altair marks his extended wings and two other small stars, pointing toward Hercules, mark his tail. Fable tells us the eagle was supposed to be the bird Jupiter kept beside his throne. Almost directly east of Altair is a beautiful little diamond of four stars which marks the head of the small Dolphin, the little fish, while a fifth star very near marks the tip of his upturned tail. This little group is better known as Job's Coffin.

Cygnus.

Lying in the Milky Way about midway between Vega and Altair is the bright star Albireo which lies in the foot of the Northern Cross, which forms a part of the constellation Cygnus. Cygnus was named by the ancient astronomers as it suggested to them the figure of a flying swan. The out-stretched wings were represented by the stars which form the arms of the cross and the upright of the cross is marked by five stars in a straight line. The star at the upper end of the cross is called Deneb and is a very brilliant star.

Deneb is so far away from us that its light cannot reach us in less than 325 years. It is a white star and sparkles almost as brightly as Vega and Spica. Deneb can be seen at some time between sunset and midnight every night in the year.

The star in the lower end of the cross, or in the head of the swan is called Albireo and is a beautiful double star. This star is interesting on account of the strong contrast in color between the two stars composing it. One is a deep blue and the other is a bright orange.

The two stars next to Albireo in the upright of the cross mark the swan's extended neck, while Deneb lies just over its heart.

Capricornus (The Goat.)

South of the Dolphin about thirty degrees is a little group of three bright stars. These stars lie in the forehead of Capricornus, the Goat. A straggling group of rather faint stars outline the remainder of the constellation, which requires a very vivid imagination to transform into the shape of a goat.

Greek mythology tells us that Capricornus is the goat into whom Bacchus once transformed himself in order to escape the furious giant Typhon.

Aquarius (The Water-Bearer.)

To the east of Capricornus is a long, faint, straggling constellation called Aquarius, the Water-Bearer. No bright stars mark this constellation. It is supposed to represent a man pouring water out of an urn which he holds on his shoulder.

Fomalhaut, the only bright star in this part of the sky, lies in the mouth of the southern fish, which is supposed to be drinking the water poured from the urn.

The Egyptians thought the Nile rose because Aquarius sank his urn into that river to fill it. The Greek, Latin and Arabic names for this constellation mean "a man pouring water."

Pisces (The Fishes.)

Just north-east of Aquarius lies a very long, straggling constellation, a group of stars at either end marking the body of the Western and Northern Fish, pointing out the constellation Pisces, the Fishes. A straggling, waving line of faint stars bind together the tails of the two fishes.

The constellation of Pisces contains no bright stars. It is made very interesting and important, however, because of the fact that in it lies the point where the ecliptic or path of the sun crosses the equator. This point is called the vernal equinox because it marks the beginning of spring.

Aries (The Ram) and Cetus (The Whale.)

Northeast of Pisces lies Aries or the Ram. The constellation is easily found, being marked by the letter "Y" of rather bright stars. Pisces and Aries are just north of the constellation Cetus, the whale. A row of bright stars curving under Pisces and Aries, extends the length of this constellation, which otherwise is faint in outline.

Aries, though a very small constellation is quite an important one, because of the fact that it is one of the constellations of the zodiac, which marks the path of the sun. The most interesting thing in Aries is the triangle formed by its chief stars.

Pegasus.

Pegasus is a large constellation composed mostly of small stars, and is supposed to represent the Winged Horse, which was the favorite of the muses. The constellation, however, bears no resemblance to a horse, but the outline of a large square known as the square of Pegasus can be easily found. Each side of the square is nearly 15° long and the stars composing it are bright enough to attract one's attention.

On the southwestern corner of the square is a small triangle. The stars forming this triangle are not very bright but they can be easily found. These stars forming the triangle are called Scheat.

The hind parts of Pegasus are hidden by the rocks on which Andromeda lies and Andromeda's head is marked by the northernmost star of the square that outlines Pegasus' body.

Pegasus rises up side down in the heavens. His fore feet are pawing in the air up towards Cygnus and the top of his head rests on Aquarius. In his journey across the sky, Pegasus does not right himself but continues to lie on his back.

According to fable Pegasus became a favorite of the muses because when he touched the earth his hoof-print left a fountain called Hippocrene.

Andromeda.

Taking the most northern star of the square of Pegasus, we find that it marks the head of Andromeda, the beautiful daughter of Cassiopeia and Cepheus. Because of her mother's boasting of her beauty, she was chained to a rock by the jealous Juno. From Andromeda's head three bright stars extend in a curving row towards the Big Dipper. The stars mark the shoulders, belt and left foot of Andromeda, while another star almost five degrees north marks her right foot. Her extended arms are represented by a row of small stars. Just north of the star in her belt, two small stars point to the wonderful nebula of Andromeda.

This nebula is the most interesting and important thing in Andromeda. It is said that this is the earliest discovered of the nebulae, and besides that in Orion is the grandest to be seen in the heavens. It is long and oval in shape and is exceedingly bright in the center. Many interesting names have been assigned to the great nebula. It has been referred to by some as the "Wisp of Light" and by others it is known as the "Queen of Nebulae."

This nebula can be seen very plainly, and to the naked eye it looks like a hazy star. It is enormous in length, and its distance is estimated to be as much as thirty thousand times the distance of the earth from the sun.

Just next to the left foot of Andromeda lies the pretty little constellation of The Triangle. It is composed of three stars of equal brightness forming an isoceles triangle. It is a pretty little object and easily found.

Perseus.

The beautiful constellation Perseus lies in the brightest part of the Milky Way, just northeast of Andromeda. Its most interesting feature is a curved line of stars extending from Cassiopeiae toward Capella, which is a very bright star in the next constellation. The line of stars

is known as the "Segment of Perseus." The brightest star in the constellation is Mirfak, lying in the center of the segment. However, the most important star in the constellation is Algol, which is south of Mirfak and forms a triangle with it and Almoch, the star in the foot of Andromeda. It is interesting because its brightness varies, which suggests that it is a double star with a dark companion. It is known as "the demon star" and "the slow winking star."

Serviss in his "Astronomy with an Opera-Glass" tells the story of Perseus and Andromeda. He says: "It will be remembered that, as Perseus was returning through the air from his conquest of the Gorgon Medusa, he saw the beautiful Andromeda chained to a rock on the sea coast, waiting to be devoured by a sea monster. The poor girl's only offense was that her mother Cassiopeiae, had boasted for her that she was fairer than the sea beauty Atergatis, and for this Neptune had decreed that all the land of the Ethiopians should be drowned and destroyed unless Andromeda was delivered up as a sacrifice to the dreadful sea monster. When Perseus, dropping down to learn why this maiden was chained to the rocks, heard from Andromeda's lips the story of her woes, he laughed with joy. Here was an adventure, and besides, unlike his previous adventures, it involved the fate of a beautiful woman, with whom he was already in love. Could he save her? Well, would'nt he! The sea monster might frighten a kingdom full of Ethiops, but it could not shake the nerves of a hero from Greece. He whispered words of encouragement to Andromeda, who could scarce believe the good news that a champion had come to defend her after all her friends and royal relations had deserted her. Neither could she feel much confidence in her young champion's powers when suddenly her horrified gaze met the awful leviathan of the deep advancing to his feast. But Perseus, with a warning to Andromeda not to look at what he was about to do, sprang with his winged sandles up into the air. And then, as Charles Kingsley has so beautifully told the story 'On came the great sea monster, coasting along like a huge black galley, lazily breasting the ripple, and stopping at times by creek or headland to watch for the laughter of girls at their bleaching, or cattle pawing on the sand hills, or boys bathing on the beach. His great sides were fringed with clustering shells and sea weeds, and the water gurgled in and out of his wide jaws as he rolled along, dripping and glistening in the beams of the morning sun. At last he saw Andromeda, and shot forward to take his prey, while the waves foamed white behind him and before him the fish fled leaping.

'Then down from the height of the air fell Perseus like a shooting star—down to the crest of the waves, while Andromeda hid her face as he shouted. And then there was silence for a while.

'At last she looked up trembling, and saw Perseus springing toward her; and instead of the monster, a long, black rock, with the sea rippling quietly round it.' Perseus had turned the monster into stone by holding the blood-freezing head of Medusa before his eyes; and it was fear least Andromeda herself might see the Gorgon's head, and suffer the fate of all who looked upon it, that had led him to forbid her watching him when he attacked her enemy. Afterward he married her, and Cassiopeia, Andromeda's mother, and Cepheus, her father, gave their daughter's rescuer a royal welcome, and all the Ethiops rose up and blessed him for ridding the land of the monster."

Auriga.

Auriga lies between Perseus and Ursa Major. The star of most importance in this constellation is Capella, which is found half way between Orion and the Pole-star and to the right of the twins. Its beamy, white light makes it one of the most beautiful stars in this part of the heavens.

The five brightest stars in Auriga outline a five sided figure which somewhat resembles a shield. Auriga is supposed to represent a man holding a goat and her two kids in his arms.

Taurus (The Bull).

In the constellation Taurus there are two remarkable clusters of stars, the Hyades and the Pleiades. The cluster of stars which form the Hyades is shaped somewhat like the letter V and Aldebaran can be found in the upper end of the left hand branch, while the Pleiades have been celebrated in all ages because of their silvery glitter. The Hyades are in the face of Taurus, the Pleiades are in the shoulder, and Aldebaran marks one of the Bull's eyes as he rushes upon Orion.

The horns start out of the head of the Bull above the Hyades, and curve upward and each horn is tipped by a bright star. These two stars which tip the end of the horns are very interesting stars. The star in the left horn of Taurus also marks the right foot of Auriga, who is standing just above. It is a white star and very bright. The star in the tip of the right horn is interesting because it is a pointer to a famous nebula.

The horns are marked by a scattered and broken line of stars that runs from the Hyades up to the tip of the horns. The constellation of Taurus is one of the easiest constellations to trace in the sky.

Orion (The Hunter).

The constellation of Orion is the most striking constellation in the heavens and is the most easily found. The great giant stands just east of Taurus, the mighty Bull, with the right arms uplifted and his

great club, marked by four little bright stars, held up in the air as if in the act of striking. A curved row of stars marks the lion's skin, which is held over his left arm. The belt of the great hunter is marked by three stars, at equal distances of one degree. A line drawn through them to the southeast points directly to Sirius in the Big Dog, the brightest star in all the sky. A glistening, yellow star marks the left shoulder of this constellation. Above the bright stars in his shoulders lies a triangle of three stars, which marks his right cheek.

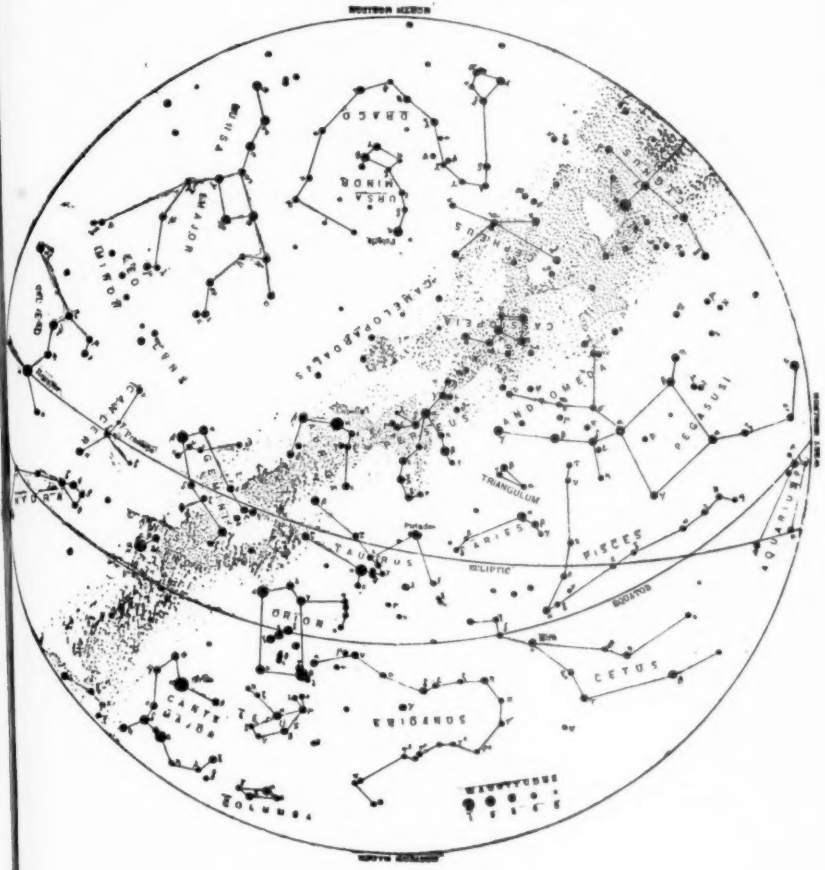
Some very interesting legends have been told concerning this constellation. Orion was supposed to be a son of Neptune and Queen Euryale, a very great Amazonian huntress, according to the legends of the Greeks. Orion was supposed to have inherited this great tendency of his mother, and was known as the greatest hunter in the world. He said there was not a single animal on earth that he was not able to overcome. Because of his great vanity, he was supposed to have been bitten on the foot, thus causing his death. After his death the goddess Diana placed him among the stars, directly opposite the Scorpion. At no time do these two constellations appear in the heavens together. As Orion goes below the western horizon, the Scorpion rises in the east. Just below the belt of Orion, we find his sword represented by a very short row of stars extending downward. Around the central star is a wisp of light known as the celebrated nebula in Orion. This is one of the first nebulae to be found in the heavens. Professor Barnard says the nebula bears resemblance to a ghostly bat flitting through the night of space.

"Regions of lucid matter taking form,
Brushes of fire, hazy gleams,
Clusters and beds of worlds, and bee-like swarms
Of suns and starry streams."

To be continued.

PLANET NOTES FOR JANUARY, 1915.

The sun will move in a northeasterly direction during the month. It will pass from the constellation Sagittarius into the constellation Capricornus. Its path for this month does not lie near any conspicuous star.



THE CONSTELLATIONS AT 9:00 P. M. JANUARY 1.

The phases of the moon for this month are as follows:

Full Moon	Jan. 2	at	6 A.M.	C. S. T.
Last Quarter	8	"	3 P.M.	"
New Moon	15	"	9 A.M.	"
First Quarter	22	"	12 P.M.	"
Full Moon	30	"	11 P.M.	"

This month will be somewhat exceptional in that there will be two full moons.

Mercury will be moving eastward more rapidly than the sun throughout the month. It will be in conjunction with the sun on January 5. It will then continue to move eastward and by the end of the month will cross the meridian one and one-third hours after the sun. It may be visible on the western horizon just after sunset at the end of the month. It will be considerably brighter than a first magnitude star at this time.

Venus will be moving eastward a little more slowly than the sun. It will therefore be getting farther to the west of the sun throughout the month. At the first of the month it will be at a period of greatest brilliancy. At this time it will be several times as bright as Sirius. It will be very conspicuous in the eastern sky in the early morning. At the end of the month it will rise a little more than three hours before the sun.

The earth will reach its point nearest the sun on January 2.

Mars will not be far enough from the sun to be visible at any time during the month. It will rise less than an hour before the sun. It will be approaching the earth and therefore be getting brighter. It will however not be in good position for observing before April.

Jupiter will be sinking so low in the west at sunset as to be practically out of reach for observations. At the end of the month it will set about an hour and a half after the sun.

Saturn will be well up in the sky shortly after sunset. It will therefore be very favorably situated for observation. It will be in the constellation Taurus not very far from the bright star Aldebaran.

Uranus will be too near the sun to be seen during this month. It will pass the sun on the last day of the month. It will at this time have nearly the same declination as the sun also.

Neptune will be at a point of opposition on January 19. It will be quite far north and will therefore rise a little before sunset. It will be found in the constellation Cancer near the western boundary. On January 16 the right ascension will be $8^h\ 5^m$, and the declination 19° 58′ north.

Occultations Visible at Washington.

Date 1915	Star's Name	Magnitude	IMMERSION. Washington M.T.	IMMERSION. Angle f'm N.	EMERSION. Washington M.T.	EMERSION. Angle f'm N.	Duration
			h m	°	h m	°	h m
Jan. 1	A Geminorum	5.1	7 57	111	9 5	258	1 8
2	η Cancri	5.5	17 30	75	18 16	342	0 45
8	75 Virginis	5.6	17 20	161	18 23	273	1 3
11	ι Scorpii	2.9	19 12	167	19 49	226	0 37
19	13 Piscium	6.4	5 46	87	6 47	198	1 1
23	26 Arietis	6.2	4 25	33	5 42	260	1 17
24	7 Tauri	5.9	13 59	16	14 19	334	0 20
27	415 B Tauri	6.1	4 19	67	5 23	277	1 4
28	39 Geminorum	6.2	5 10	109	6 13	252	1 3
28	40 Geminorum	6.3	5 52	164	6 12	198	0 20
29	9 Cancri	6.2	12 23	90	13 33	326	1 10
31	χ Leonis	5.6	7 20	75	8 11	328	0 51

Saturn's Satellites for January 1915.

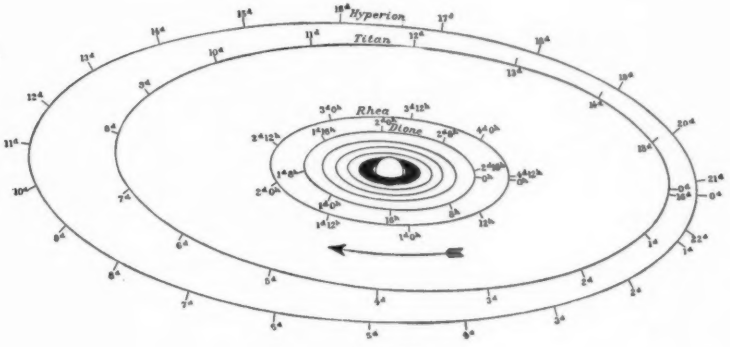
CENTRAL STANDARD TIME.

E = eastern elongation; W = western elongation;
I = inferior conjunction; S = superior conjunction.

I. Mimas. Period $0^d\ 22^h.6$

		h			h			h			h
Jan.	1	14.7 W	Jan.	8	16.0 E	Jan.	16	5.1 E	Jan.	24	5.4 W
	2	13.3 W		9	14.8 E		17	15.1 W		25	15.3 E
	3	11.9 W		10	13.4 E		18	13.5 W		26	13.9 E
	4	10.5 W		11	12.0 E		19	12.3 W		27	12.5 E
	5	9.1 W		12	10.7 E		20	10.9 W		28	11.1 E
	6	7.7 W		13	9.3 E		21	9.5 W		29	9.7 E
	7	6.3 W		14	7.9 E		22	8.1 W		30	8.3 E
	8	4.9 E		15	6.5 E		23	6.7 W		31	6.9 E

South



North

Apparent Orbits of the Seven Inner Satellites of Saturn, at date of Opposition, December 6, 1913, as seen in an Inverting Telescope.

II. Enceladus. Period $1^d\ 8^h.8$

		h			h			h			h
Jan.	1	6.2 E	Jan.	9	11.5 E	Jan.	17	16.7 E	Jan.	25	22.0 E
	2	15.1 E		10	20.4 E		19	1.6 E		27	6.9 E
	4	0.0 E		12	5.2 E		20	10.5 E		28	15.8 E
	5	8.9 E		13	14.1 E		21	19.4 E		30	0.7 E
	6	17.7 E		14	23.0 E		23	4.3 E		31	9.5 E
	8	2.6 E		16	7.9 E		24	13.1 E			

III. Tethys. Period $1^d\ 21^h.3$

Jan.	1	4.1 E	Jan.	10	14.5 E	Jan.	18	3.7 E	Jan.	25	16.9 E
	3	1.4 E		12	11.8 E		20	1.0 E		27	14.2 E
	4	22.7 E		14	9.1 E		21	22.3 E		29	11.5 E
	6	20.0 E		16	6.4 E		23	19.6 E		31	8.8 E
	8	17.3 E									

IV. Dione. Period $2^d\ 17^h.7$

Jan.	1	0.1 E	Jan.	9	5.0 E	Jan.	17	10.0 E	Jan.	25	14.9 E
	3	17.7 E		11	22.7 E		20	5.6 E		28	8.6 E
	6	11.4 E		14	16.3 E		22	21.3 E		31	2.3 E

V. Rhea. Period $4^d\ 12^h.5$

		h			h			h			h
Jan.	2	11.9 E	Jan.	11	12.5 E	Jan.	20	13.1 E	Jan.	29	13.8 E
	7	0.2 E		16	0.8 E		25	1.5 E			

VI. Titan. Period $15^d\ 23^h.3$

Jan.	2	23.0 E	Jan.	10	19.2 W	Jan.	18	20.4 E	Jan.	26	16.7 W
	6	22.3 I		15	18.5 S		22	19.8 I		30	16.0 S

VII. Hyperion. Period $21^d\ 7^h.6$

Jan.	1.3 W	Jan.	11.7 E	Jan.	22.4 W	Jan.	28.2 S
	7.0 S		16.5 I				

VIII. Japetus. Period $79^d\ 22^h.1$

Jan. 20.0 E

IX. Phoebe. Period $580^d\ 2^h.9$

	α Ph.−α Sat.			δ Ph.−δ Sat.			α Ph.−α Sat.			δ Ph.−δ Sat.		
		m	s	′	″			m	s	′	″
Jan.	1	−2	25.4	−2	11	Jan.	17	−2	26.2	−3	2
	5	2	26.1	2	25		21	2	25.4	3	12
	9	2	26.5	2	38		25	2	24.4	3	22
	13	−2	26.5	−2	50		29	−2	22.9	−3	30

VARIABLE STARS.

Confirmation of Variability of two Stars.—In *A.N.* 4761, M. Luizet gives the conclusions reached from his observations upon the variable stars 55.1911 Trianguli and 23.1911 Persei. These observations extend over the past two or three years and show that the former has a period of about 113 days and that the latter has a period of about 2½ years.

Provisional Elements of three Variables.—In *A. N.* 4761, M. Luizet gives the ollowing as provisional elements to the three stars TV Persei, TX Persei and UX Aurigae.

TV Persei	Max. = 2419480 + 234 E
TX Persei	Max. = 2419378 + 105 E, M − m = 45^d.
UX Aurigae	Max. = 2418027 + 102.7 E, M − m = 56^d.

Suspected Variable.—In *A.N.* 4761, M. Luizet states that a star, in position in 1855 $\alpha = 2^h\ 38^m\ 41^s$ $\delta = +36°\ 21'$, is probably variable. The observations show a change in magnitude from 9.7 to 10.5. It is given the designation 91.1914 Persei.

Approximate Magnitudes of Variable Stars of Long Period on Nov. 1, 1914.

[Communicated by the Director of Harvard College Observatory, Cambridge, Mass.]

Name.	R. A. 1900.	Decl. 1900.	Magn.	Name.	R.A. 1900	Decl. 1900	Magn.
	h m	° ′			h m	° ′	
X Androm.	0 10.8	+46 27	<10.0	RU Ophiuchi	17 28.5	+ 9 30	9.8
T Androm.	17.2	+26 26	12.3	T Draconis	54.8	+58 14	10.8
T Cassiop.	17.8	+55 14	8.3	RY Herculis	55.4	+19 29	9.0
S Ceti	19.0	— 9 53	10.5	T Herculis	18 5.3	+31 0	9.4*d*
U Cassiop.	40.8	+47 43	<12.0	W Lyrae	11.5	+36 38	11.6
RW Androm.	41.9	+32 08	<11.0	X Ophiuchi	33.6	+ 8 44	6.6
RR Androm.	45.9	+33 50	10.2 *i*	R Scuti	42.2	— 5 49	5.6
RV Cassiop.	47.1	+46 53	10.0 *i*	R Aquilae	19 1.6	+ 8 5	6.2
W Cassiop.	49.0	+58 1	11.0 *i*	TY Cygni	29.8	+28 6	<11.0
U Androm.	1 9.8	+40 11	<11.0	RT Aquilae	33.3	+11 30	11.0
S Piscium.	12.4	+ 8 24	10.6 *i*	RV Aquilae	35.9	+ 9 42	<13.0
R Piscium	25.5	+ 2 22	8.5 *i*	RT Cygni	40.8	+48 32	8.0
X Cassiop.	49.8	+58 46	10.0	TU Cygni	43.3	+48 49	11.4*d*
U Persei	53.0	+54 20	9.6 *i*	X Aquilae	46.5	+ 4 13	13.6
R Arietis	2 10.4	+24 35	10.0*d*	χ Cygni	46.7	+32 40	6.6 *i*
o Ceti	14.3	— 3 26	9.0	Z Cygni	58.6	+49 46	12.2*d*
S Persei	15.7	+58 8	11.8	SY Aquilae	20 2.3	+12 39	<12.0
R Ceti	20.9	— 0 38	10.8*d*	S Cygni	3.4	+57 42	<13.0
RR Persei	21.7	+50 49	11.8*d*	S Aquilae	7.0	+15 19	9.5
R Trianguli	31.0	+33 50	7.6*d*	R Delphini	10.1	+ 8 47	10.2*d*
Y Persei	3 20.9	+43 50	10.0	RT Sagittarii	11.1	—39 25	9.6*d*
R Persei	23.7	+35 20	12.8	U Cygni	16.5	+47 35	7.2
R Tauri	4 22.8	+ 9 56	<10.0	RW Cygni	25.2	+39 39	8.4
W Tauri	22.2	+15 49	10.0*d*	Z Delphini	28.1	+17 7	8.4 *i*
S Tauri	23.7	+ 9 44	<10.0	Y Delphini	36.9	+11 31	13.0
X Camelop.	32.6	+74 56	11.6*d*	S Delphini	38.5	+16 44	11.0*d*
R Aurigae	5 9.2	+53 28	11.2 *i*	V Cygni	38.1	+47 47	9.6
S Aurigae	20.5	+34 4	8.8	T Delphini	40.7	+16 2	9.8*d*
U Orionis	49.9	+20 10	10.3*d*	V Delphini	43.2	+18 58	<12.0
S Can. Min.	7 27.3	+ 8 32	9.3 *i*	T Aquarii	44.7	— 5 31	11.0*d*
R Leonis	9 42.2	+11 54	8.4	RZ Cygni	48.5	+46 59	11.1
R Urs. Maj.	10 37.6	+69 18	<10.0	R Vulpeculae	59.9	+23 26	8.6 *i*
T Urs. Maj.	12 31.8	+60 2	<11.0	TW Cygni	21 1.8	+29 0	11.2*d*
S Urs. Maj.	39.6	+61 38	8.0	T Cephei	8.2	+68 5	6.2 *i*
T Urs. Min.	13 32.6	+73 56	9.8 *i*	S Cephei	36.5	+78 10	9.6
U Urs. Min.	14 15.1	+67 15	10.8 *i*	RU Cygni	37.3	+53 52	8.6
S Bootis	19.5	+54 16	10.2 *i*	V Pegasi	56.0	+ 5 38	13.9
R Camelop.	25.1	+84 17	8.6 *i*	T Pegasi	22 4.0	+12 3	<13.0
R Bootis	32.8	+27 10	9.6*d*	Y Pegasi	6.8	+13 52	<12.0
S Cor. Bor.	15 17.3	+31 44	11.2 *i*	RS Pegasi	7.4	+14 4	9.0
S Urs. Min.	33.4	+78 58	10.0*d*	S Lacertae	24.6	+39 48	11.8
R Herculis	16 1.7	+18 38	<13.0	S Aquarii	51.8	—20 53	<12.0
U Serpentis	2.5	+10 12	9.8 *i*	R Pegasi	23 1.6	+10 0	8.2
RU Herculis	6.0	+25 20	13.3	V Cassiop.	7.4	+59 8	11.2*d*
W Cor. Bor.	11.8	+38 3	11.2*d*	W Pegasi	14.8	+25 44	11.2*d*
U Herculis	21.4	+19 7	12.0	S Pegasi	15.5	+ 8 22	10.8*d*
W Herculis	31.7	+37 32	8.4*d*	ST Androm.	33.8	+35 13	9.0
R Draconis	32.4	+66 58	8.6 *i*	R Aquarii	38.6	—15 50	8.2*d*
S Herculis	47.4	+15 7	10.4*d*	Z Cassiop.	39.7	+56 2	<13.0
RV Herculis	56.8	+31 22	<13.0	R Cassiop.	53.3	+50 50	6.4*d*
				Z Pegasi	55.0	+25 21	12.0

The letter *i* denotes that the light is increasing; the letter *d*, that the light is decreasing; the sign < that the variable is fainter than the appended magnitude.

The above magnitudes have been compiled at the Harvard College Observatory from observations made by the following observers:—H. L. Baldwin, T. C. H. Bouton, A. T. Bolfing, A. B. Burbeck, A. P. C. Craig, H. O. Eaton, F. H. Hay, S. C. Hunter, S. H. Huntington, M. W. Jacobs, Jr., J. B. Lacchini, F. C. Leonard, C. B. Lindsley, O. Mach, C. Y. McAteer, C. S. Mundt, W. T. Olcott, D. B. Pickering, C. Richter, F. H. Spinney, H. M. Swartz, H. W. Vrooman, I. E Woods, and A. S. Young.

Minima of Variable Stars of Short Period.

[Calculated by Elva Utzinger and C. D. Hibbard at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5^h; Central Standard 6^h; etc.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1915 January.							
	h m	° ′		d h	d	h	d	h	d	h	d	h
SY Androm.	0 08.0	+43 09	9.5—13.0	34 21.8			21	6				
RT Sculptor.	31.5	−26 13	9.6—10.5	0 12.3	6	12;	14	4;	21	20;	29	12
UU Androm.	38.5	+30 24	10.7—11.9	1 11.7	5	12;	12	23;	20	9;	27	19
U Cephei	0 53.4	+81 20	7.0— 9.0	2 11.8	6	7;	13	19;	21	6;	28	17
Z Persei	2 33.7	+41 46	9.4—12	3 01.4	4	17;	10	19;	16	22;	23	1
TW Cassiop.	37.6	+65 19	8.2— 9.0	1 10.3	6	23:	14	2;	21	6;	28	9
RY Persei	39.0	+47 43	8.0—10.3	6 20.7	4	7;	11	4;	18	0;	24	21
RZ Cassiop.	39.9	+69 13	6.9— 8.1	1 04.7	8	3;	15	7;	22	11;	29	15
TX Cassiop.	44.4	+62 22	9.4—10.1	2 22.2	3	10;	12	4;	20	23;	29	18
ST Persei	53.7	+38 47	8.5—10.5	2 15.6	7	16;	15	14;	23	13;	31	12
RX Cassiop.	58.8	+67 11	8.6— 9.1	32 07.6			18	12				
Algol	3 01.7	+40 34	2.3— 3.5	2 20.8	5	21;	11	15;	17	9;	23	2
RT Persei	16.7	+46 12	9.5—11.5	0 20.4	1	3;	7	22;	14	17;	21	12
λ Tauri	55.1	+12 12	3.3— 4.2	3 22.9	4	17;	12	14;	20	12;	28	10
RW Tauri	3 57.8	+27 51	7.1—<11	2 18.5	9	6;	17	13;	25	21		
RV Persei	4 04.2	+33 59	9.5—11.0	1 23.4	2	10;	10	8;	18	5;	26	2
RW Persei	13.3	+42 04	8.8—11.0	15 04.8	8	11;	21	16				
SZ Tauri	31.4	+18 20	7.2— 7.7	3 03.6	4	23;	14	10;	23	21		
RS Cephei	4 48.6	+80 06	9.5—12.0	12 10.1	8	7;	20	17				
TT Aurigae	5 02.8	+39 27	7.8— 8.7	0 16.0	7	6;	13	22;	20	14;	27	6
RY Aurigae	11.5	+38 13	10.7—11.7	2 17.5	2	16;	8	3;	19	1;	29	23
RZ Aurigae	42.9	+31 40	10.6—13.3	3 00.3	5	2;	11	2;	17	3;	23	3
SV Tauri	45.8	+28 05	9.4—11.0	2 04.0	5	13;	14	5;	22	21;	31	13
Z Orionis	50.2	+13 40	9.7—10.7	5 04.9	4	15;	15	1;	25	11		
SV Gemin.	54.6	+24 28	9.8—<11	4 00.2	7	16;	15	17;	23	17;	31	17
RW Gemin.	5 55.4	+23 08	9.5—11.0	2 20.8	2	12;	8	6;	19	17;	31	4
U Columbae	6 11.2	−33 03	9.2—10.0	2 19.2	2	15;	8	5;	19	10;	30	15
SX Gemin.	22.0	+20 37	10.8—11.5	1 08.8	6	19;	15	0;	23	5;	31	10
RW Monoc.	29.3	+ 8 54	9.0—10.8	1 21.7	3	15;	11	6;	18	21;	26	12
RX Gemin.	43.6	+33 21	8.8— 9.6	12 05.0			11	8;	23	13		
RU Monoc.	6 49.4	− 7 28	9.8—10.5	0 21.5	6	15;	13	19;	20	23;	28	3
R Can. Maj.	7 14.9	−16 12	5.8— 6.4	1 03.3	3	16;	12	18;	21	20;	30	22
RY Gemin.	21.7	+15 52	8.9—<10	9 07.2	9	21;	19	4;	28	11		
Y Camelop.	27.6	+76 17	9.5—12	3 07.3	3	3;	13	1;	22	23		
TX Gemin.	30.3	+17 8	10.0—11.9	2 19.2	5	15;	14	0;	22	10;	30	20
RR Puppis	43.5	−41 08	9.4—10.7	6 10.3	2	8;	8	18;	15	5;	21	15
V Puppis	7 55.4	−48 58	4.1— 4.8	1 10.9	6	14;	13	21;	21	3;	28	10
X Carinae	8 29.1	−58 53	7.9— 8.7	0 13.0	3	23;	12	2;	20	5;	28	8
S Cancri	8 38.2	+19 24	8.2—10	9 11.6	2	23;	12	10;	21	22;	31	10
RX Hydrae	9 0.8	− 7 52	9.1—10.5	2 6.8	1	11;	10	14;	19	17;	28	20
S Antliae	27.9	−28 11	6.3— 6.8	0 07.8	1	0;	7	12;	14	0;	20	11
S Velorum	29.4	−44 46	7.8— 9.3	5 22.4	5	19;	11	17;	17	16;	23	14
Y Leonis	9 31.1	+26 41	9.3—11.2	1 16.5	1	11;	9	22;	18	8;	26	18
RR Velorum	10 17.8	−41 36	10.0—10.9	1 20.5	3	2;	12	9;	21	16;	30	22
SS Carinae	10 54.2	−61 23	12.2—12.8	3 07.2	6	13;	13	3;	19	18;	26	8
ST Urs. Maj.	11 22.4	+45 44	6.7— 7.2	8 19.2	1	10;	10	5;	19	0;	27	19
RW Urs. Maj.	35.4	−52 34	10.3—11.4	7 07.9	6	8;	13	16;	21	0;	28	8
Z Draconis	11 39.8	+72 49	9.9—13.6	1 08.6	1	10;	8	5;	15	0;	21	19
RZ Centauri	12 55.6	−64 05	8.5— 8.9	1 21.0	3	13;	11	1;	18	13;	26	2
SS Centauri	13 07.2	−63 37	8.8—10.4	2 11.5	7	3;	14	13;	22	0;	29	10
δ Librae	14 55.6	− 8 07	4.8— 6.2	2 07.9	1	9;	8	9;	15	8;	22	8
U Coronae	15 14.1	+32 01	7.6— 8.7	3 10.9	6	0;	12	21;	19	19;	26	17
TW Draconis	32.4	+64 14	7.3— 8.9	2 19.4	8	5;	16	15;	25	1		
SS Librae	15 43.4	−15 14	9.3—11.5	0 18.4	6	6;	13	22;	21	14;	29	6

Minima of Variable Stars of Short Period.—Continued.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1915 January.							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
SW Ophiuchi	16 11.1	— 6 44	9.2—10.0	2 10.7	6 12;	13 20;	21 4;	28 12				
SX Ophiuchi	12.6	— 6 25	10.5—11.2	2 01.5	1 19;	10 1;	18 7;	26 13				
R Arae	31.1	−56 48	6.8— 7.9	4 10.2	5 14;	14 10;	23 7					
TT Herculis	16 49.9	+17 00	8.9— 9.3	20 18.1		11 12;	21 5					
TU Herculis	17 09.8	+30 50	9.5—12	2 06.4		21 17;	28 12					
U Ophiuchi	11.5	+ 1 19	6.0— 6.7	0 20.1	4 11;	12 21;	21 6;	29 15				
u Herculis	13.6	+33 12	4.6— 5.4	2 01.2	5 2;	11 6;	17 9;	23 13				
TX Herculis	15.4	+42 00	8.3— 9.0	1 00.7	4 24;	12 5;	19 10;	26 15				
RV Ophiuchi	29.8	+ 7 19	9. —12	3 16.5	7 19;	15 4;	22 13;	29 22				
SZ Herculis	36.0	+33 01	9.5—10.3	0 19.6	1 13;	9 17;	17 22;	26 2				
TX Scorpii	48.6	−34 13	7.5— 8.2	0 22.6	1 18;	9 6;	16 19;	24 8				
UX Herculis	49.7	+16 57	8.8—10.5	1 13.2	7 7;	15 1;	22 19;	30 12				
Z Herculis	53.6	+15 09	7.1— 7.9	3 23.8	2 22;	10 21;	18 21;	26 21				
WX Sagittae	53.6	−17 24	9.2—10.8	2 03.1	3 1;	11 19;	20 8;	28 20				
WY Sagittae	17 54.9	−23 1	9.5—10.6	4 16.0	1 2;	10 10;	19 18;	29 2				
SX Draconis	18 03.0	+58 23	9.3—10.5	5 04.1	4 23;	15 7;	25 15					
RS Sagittarii	11.0	−34 08	5.9— 6.3	2 10.0	3 22;	11 4;	18 10;	25 16				
V Serpentis	11.1	−15 34	9.5—11.1	3 10.9	3 6;	10 4;	17 2;	23 23				
RZ Scuti	21.1	− 9 15	7.4— 8.3	15 03.2	3 23;	19 2						
RZ Draconis	21.8	+58 50	9.5—10.2	0 13.2	2 9;	10 15;	18 21;	27 4				
RX Herculis	26.0	+12 32	7.0— 7.6	0 21.3	8 23;	17 21;	26 18					
SX Sagittarii	39.7	−30 36	8.7— 9.8	2 01.8	9 3;	17 11;	25 18					
RR Draconis	40.8	+62 34	9.3—13	2 19.9	2 10;	10 22;	19 9;	27 21				
RS Scuti	43.7	−10 21	9.3—10.3	0 15.9	1 20;	8 12;	15 3;	21 19				
β Lyrae	46.4	+33 15	3.4— 4.1	12 21.8		10 10;	23 7					
U Scuti	18 48.9	−12 44	9.1— 9.6	0 22.9	4 22;	14 11;	24 0					
RX Draconis	19 01.1	+58 35	9.3—10.2	1 21.4	5 2;	13 16;	20 6;	27 19				
RV Lyrae	12.5	+32 15	11. —12.8	3 14.4	4 11;	11 16;	18 21;	26 1				
RS Vulpec.	13.4	+22 16	6.9— 8.0	4 11.4	9 20;	18 19;	27 18					
U Sagittae	14.4	+19 26	6.5— 9.0	3 09.1	2 21;	9 15;	16 9;	23 4				
Z Vulpec.	17.5	+25 23	7.3— 8.5	2 10.9	6 14;	13 22;	21 7;	28 16				
TT Lyrae	24.3	+41 30	9.3—11.6	5 05.8	5 22;	11 4;	16 10;	21 16				
UZ Draconis	26.1	+68 44	9.0— 9.8	1 15.1	4 5;	10 18;	17 6;	23 19				
SY Cygni	19 42.7	+32 28	10 —12	6 00.2	2 23;	8 23;	14 23;	20 23				
WW Cygni	20 00.6	+41 18	9.3—13.4	3 07.6	6 17;	13 8;	20 0;	26 15				
SW Cygni	03.8	+46 01	9. —11.7	4 13.8	5 5;	14 8;	23 12					
VW Cygni	11.4	+34 12	9.8—11.8	8 10.3	6 18;	15 5;	23 15					
RW Capric.	12.2	−17 59	8.8—10.6	3 09.4	7 6;	14 1;	20 20;	27 15				
UW Cygni	19.6	+42 55	10.5—13	3 10.8	3 2;	9 23;	16 21;	23 19				
V Vulpec.	32.3	+26 15	8.2—9.8	37 19.0								
W Delphini	33.1	+17 56	9.4—12.1	4 19.4	2 5;	11 19;	21 10;	31 1				
RR Delphini	38.9	+13 35	10.5—11.8	4 14.4	3 11;	12 15;	21 20;	31 1				
Y Cygni	48.1	+34 17	7.1— 7.9	1 12.0	6 17;	14 4;	21 16;	29 4				
WZ Cygni	49.3	+38 27	9.9—10.8	0 14.0	2 16;	8 12;	20 4;	31 21				
RR Vulpec.	20 50.5	+27 32	9.6—11.0	5 01.2	1 10;	11 12;	21 15;	31 17				
VV Cygni	21 02.3	+45 23	12.1—13.8	1 11.4	7 8;	14 17;	22 2;	29 11				
AE Cygni	09.0	+30 20	10.8—11.4	0 23.3	3 22;	13 15;	23 7					
RY Aquarii	14.8	−11 14	8.8—10.4	1 23.2	5 15;	13 12;	21 9;	29 6				
UZ Cygni	55.2	+43 52	8.9—11.6	31 07.3	3 23							
RT Lacertae	21 57.4	+43 24	9.1—10.5	5 01.7	1 21;	12 1;	22 4					
RW Lacertae	22 40.6	+49 08	10.2—11.2	5 04.4	5 5;	10 9;	20 18;	31 3				
X Lacertae	22 45.0	+55 54	8.2— 8.6	5 10.6	6 2;	11 13;	17 0;	22 10				
TT Androm.	23 08.7	+45 36	11.3—12.6	2 18.3	2 11;	10 18;	19 1;	27 9				
Y Piscium	29.3	+ 7 22	9.0—12.0	3 18.4	7 17;	15 6;	22 19;	30 7				
TW Androm.	23 58.2	+32 17	8.6—11.5	4 02.9	2 16;	10 22;	19 4;	27 9				

Maxima of Variable Stars of Short Period.

[Calculated by Julia M. Hawkes and Agnes E. Wells at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time. To obtain Eastern standard time subtract 5h; Central standard time 6h; etc.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1915. January.							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
SX Cassiop.	0 05.5	+54 20	8.6— 9.4	36 13.7			10 6					
SY Cassiop.	0 09.8	+57 52	9.3— 9.9	4 1.7	2 2;	10 5;	18 9;	26 12				
RR Ceti	1 27.0	+ 0 50	8.3— 9.0	0 13.3	6 9;	14 3;	21 20;	29 14				
RW Cassiop.	1 30.7	+57 15	8.9—11.0	14 19.2		12 22;	27 17					
V Arietis	2 09.6	+11 46	8.3— 9.0	0 23.8	6 4;	14 3;	22 1;	30 0				
SU Cassiop.	2 43.0	+68 28	6.5— 7.0	1 22.8	5 4;	12 23;	20 18;	28 13				
TU Persei	3 01.8	+52 49	11.4—12.2	0 14.6	3 14;	10 21;	18 4;	25 11				
RW Camelop.	3 46.2	+58 21	8.2— 9.4	16 00.0		15		31				
SX Persei	4 10.2	+41 27	10.4—11.2	4 07.0	7 9;	15 23;	24 13					
SV Persei	42.8	+42 07	8.8— 9.6	11 03.1	3 14;	14 18;	25 21					
RX Aurigae	4 54.5	+39 49	7.2— 8.1	11 15.0	3 7;	14 22;	26 13					
SX Aurigae	5 04.6	+42 02	8.0— 8.7	1 12.8	5 2;	12 18;	20 10;	28 2				
SY Aurigae	05.5	+42 41	8.4— 9.5	10 03.3	1 10;	11 14;	21 17;	31 20				
Y Aurigae	21.5	+42 21	8.6— 9.6	3 20.6	1 2;	8 19;	16 12;	24 6				
RZ Gemin.	5 56.6	+22 12	9.1—10.0	5 12.7	3 5;	8 18;	19 9;	31 21				
RS Orionis	6 16.5	+14 44	8.2— 8.9	7 13.6	1 5;	8 18;	16 8;	31 11				
T Monoc.	19.8	+ 7 08	5.7— 6.8	27 00.3		21 13						
RZ Camelop.	23.7	+67 06	11.0—13.0	0 11.5	7 9;	14 13;	21 18;	28 23				
W Gemin.	6 29.2	+15 24	6.7— 7.5	7 22.0	3 14;	11 12;	19 10;	27 8				
ζ Gemin.	6 58.2	+20 43	3.7— 4.3	10 03.7	1 23;	12 3;	22 6					
RU Camelop.	7 10.9	+69 51	8.5— 9.8	22 06.5		17 2						
RR Gemin.	7 15.2	+31 04	10.0—11.5	0 09.5	4 3;	12 2;	20 1;	27 23				
V Carinae	8 26.7	−59 47	7.4— 8.1	6 16.7	5 9;	12 2;	18 18;	25 11				
T Velorum	8 34.4	−47 01	7.6— 8.5	4 15.3	8 8;	17 14;	26 21					
V Velorum	9 19.2	−55 32	7.5— 8.2	4 08.9	4 18;	13 12;	22 6;	30 23				
Z Leonis	9 46.4	+27 22	7.9— 9.6	59 0.0								
RR Leonis	10 02.1	+24 29	9.1—10.1	0 10.9	6 8;	13 3;	19 22;	26 17				
SU Draconis	11 32.2	+67 53	8.9— 9.6	0 15.8	4 20;	11 10;	18 1;	24 15				
S Muscae	12 07.4	−69 36	6.4— 7.3	9 15.8	7 16;	17 9;	26 0					
SW Draconis	12.8	+70 04	8.8— 9.6	0 13.7	5 3;	13 3;	21 2;	29 2				
T Crucis	15.9	−61 44	6.8— 7.6	6 17.6	3 14;	10 8;	17 2;	23 19				
R Crucis	18.1	−61 04	6.8— 7.9	5 19.8	4 18;	10 14;	16 10;	22 5				
S Crucis	12 48.4	−57 53	6.5— 7.6	4 16.6	2 1;	11 10;	20 19;	29 4				
W Virginis	13 20.9	− 2 52	8.7—10.4	17 06.5		16 19						
SS Hydrae	25.0	−23 08	7.4— 8.1	8 4.8	5 0;	13 5;	21 10;	29 14				
RV Urs. Maj.	13 29.4	+54 31	9.2— 9.9	0 11.2	3 7;	10 7;	17 8;	24 8				
ST Virginis	14 22.5	− 0 27	10.3—11.4	0 09.9	1 16;	9 21;	18 2;	26 7				
V Centauri	25.4	−56 27	6.4— 7.8	5 11.9	4 23;	10 11;	15 23;	21 11				
RS Bootis	29.3	+32 11	8.9—10.0	0 09.1	1 16;	9 5;	16 18;	24 7				
RU Bootis	14 41.5	+23 44	12.8—14.3	0 11.9	6 18;	14 4;	21 14;	28 24				
R Triang. Austr.	15 10.8	−66 08	6.7— 7.4	3 09.3	7 14;	14 9;	21 4;	27 22				
S Triang. Austr.	15 52.2	−63 29	6.4— 7.4	6 07.8	1 5;	7 13;	13 21;	20 4				
S Normae	16 10.6	−57 39	6.6— 7.6	9 18.1	2 14;	12 9;	22 3;	31 21				
RW Draconis	33.7	+58 03	9.6—10.8	0 10.6	9 20;	18 17;	27 14					
RV Scorpii	16 51.8	−33 27	6.7— 7.4	6 01.5	2 5;	8 6;	14 8;	20 9				
X Sagittarii	17 41.3	−27 48	4.4— 5.0	7 00.3	5 4;	12 5;	19 5,	26 5				
Y Ophiuchi	47.3	− 6 07	6.1— 6.5	17 02.9	9 13;	26 16						
W Sagittarii	17 58.6	−29 35	4.3— 5.1	7 14.3	1 7;	8 21;	16 12;	24 2				
Y Sagittarii	18 15.5	−18 54	5.4— 6.2	5 18.6	5 17;	11 12;	17 6;	23 1				
U Sagittarii	26.0	−19 12	6.5— 7.3	6 17.9	1 12;	8 6;	14 23;	21 17				
Y Scuti	32.6	− 8 27	8.7— 9.2	10 08.3	9 19;	20 3;	30 12					
Y Lyrae	34.2	+43 52	11.3—12.3	0 12.1	3 16;	9 16;	15 17;	21 18				
RZ Lyrae	39.9	+32 42	9.9—11.2	0 12.3	1 10;	7 13;	13 17;	19 20				

Maxima of Variable Stars of Short Period.—Continued.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1915. January.							
	h m	° ′		d h	d	h	d	h	d	h	d	h
RT Scuti	44.1	−10 30	9.1— 9.7	0 11.9	2	17;	8	16;	14	14;	20	13
κ Pavonis	18 46.6	−67 22	3.8— 5.2	9 02.2	4	12;	13	15;	22	17;	31	19
U Aquilae	19 24.0	− 7 15	6.2— 6.9	7 00.6	4	11;	11	11;	18	12;	25	13
XZ Cygni	30.4	+56 10	8.6— 9.3	0 11.2	6	9;	13	9;	20	8;	27	8
U Vulpec.	32.2	+20 07	6.5— 7.6	7 23.5	6	12;	14	11;	22	11;	30	10
SU Cygni	40.8	+29 01	6.2— 7.0	3 20.3	3	23;	11	15;	19	8;	27	0
η Aquilae	47.4	+ 0 45	3.7— 4.5	7 04.2	5	18;	12	22;	20	2;	27	6
S Sagittae	51.5	+16 22	5.6— 6.4	8 09.2	3	23;	11	8;	19	17;	28	2
X Vulpec.	19 53.3	+26 17	9.5—10.5	6 07.7	5	13;	11	20;	18	4;	24	11
X Cygni	20 39.5	+35 14	6.0— 7.0	16 09.3			15	12;	31	21		
T Vulpec.	47.2	+27 52	5.5— 6.1	4 10.5	5	5;	14	2;	22	23;	31	19
WY Cygni	52.3	+30 03	9.6—10.4	0 13.5	4	16;	11	10;	18	3;	24	21
RV Capric.	55.9	−15 37	9.2—10.1	0 10.7	4	22;	11	15;	18	9;	25	2
TX Cygni	20 56.4	+42 12	8.5— 9.7	14 17.4	5	13;	20	6				
VY Cygni	21 00.4	+39 34	8.8— 9.5	7 20.6	6	22;	14	19;	22	15;	30	12
SW Aquarii	10.2	− 0 20	9.9—10.8	0 11.0	1	8;	8	5;	15	3;	20	0
VZ Cygni	21 47.7	+42 40	8.2— 9.2	4 20.7	2	10;	12	3;	21	21;	31	14
Y Lacertae	22 05.2	+50 33	9.1— 9.6	4 07.8	7	3;	15	19;	24	10		
δ Cephei	25.5	+57 54	3.7— 4.6	5 08.8	4	18;	10	3;	20	20;	31	14
Z Lacertae	36.9	+56 18	8.2— 9.0	10 21.1	1	3;	12	0;	22	21		
RR Lacertae	37.5	+55 55	8.5— 9.2	6 10.1	2	17;	9	3;	15	13;	21	23
V Lacertae	22 44.5	+55 48	8.2— 8.9	4 23.6	5	10;	10	11;	20	9;	30	8
SW Cassiop.	23 03.7	+58 11	9.2— 9.7	5 10.6	4	0;	9	11;	20	8;	31	5
RS Cassiop.	32.6	+61 52	9.0—11.0	6 07.1	1	21;	8	4;	14	11;	20	18
RY Cassiop.	47.2	+58 11	9.3—11.8	12 03.4	1	14;	13	17;	25	20		
V Cephei	23 51.7	+82 38	6.0— 7.0	0 23.9	4	16;	9	15;	19	15;	29	14

COMET AND ASTEROID NOTES.

Encke's Comet.—This comet unexpectedly brightened up in the latter part of October, and is reported to have been as bright as magnitude 7 on October 26. During this month it will be too near the sun to be observed.

Comet 1914 *e* (Campbell).—This comet appears to have been discovered independently by several persons: Campbell at Arequipa, Peru, Westland at Wellington, New Zealand, and Lunt at Cape of Good Hope, on Sept. 18, Thomas at Glenorchy, Tasmania, on Sept. 20, Hagerty at Las Cruces, New Mexico, on Sept.

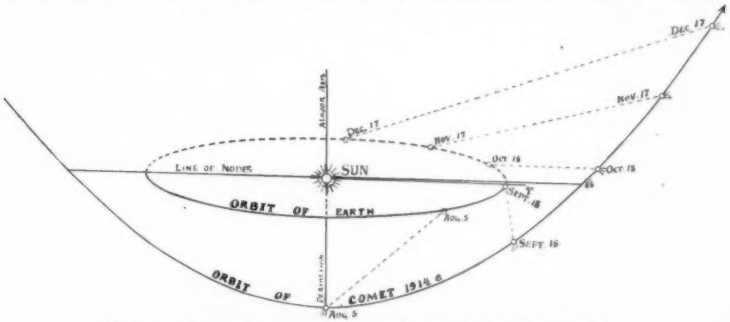


FIG. 1. DIAGRAM OF THE ORBIT OF COMET 1914 *e* (CAMPBELL).

25, and others for whom the dates are not given. The date of Campbell's discovery was not given in the announcement, but Professor Pickering informs us that Campbell saw the comet at 1 o'clock on the morning of Sept. 18, i.e. about Sept. 17.5 G.M.T.

On the above dates the comet was visible to the naked eye, but it diminished so rapidly in brightness that, when it came into the range of northern observers after the full moon in October, it was only a telescopic object and now it has become invisible even with large telescopes. The reason for this is apparent in the accompanying diagram, which has been prepared by the aid of the elements computed by Miss Lamson of the U. S. Naval Observatory, which are given below. In the diagram the earth's orbit is projected on the plane of the comet's orbit, the angle between the two planes being about 78°. The comet was nearest the sun August 5 but was then as far away from the earth as the sun is. At the time it was discovered it was at about its nearest point of approach to the earth. Since that time the comet and earth have been separating very rapidly, and now it is about twice as far off as the sun.

Elements and Ephemeris of Comet *e* 1914 (Campbell)

By Eleanor A. Lamson.

[Communicated by Captain J. A. Hoogewerff, U.S.N., Superintendent U. S. Naval Observatory].

From observations of Oct. 1, 10 and 18 made at Washington by H. E. Burton, the following elements were computed:

Elements.

T = 1914 Aug. 4.9946 G.M.T.
π = 270° 49′ 29″.8
Ω = 0 22 22 .3
i = 77 50 24 .2
q = 0.713825

A comparison with an observation Oct. 23, made at Washington gives the following residuals:

$(O-C)$ $\Delta\lambda$ = — 0″.8
$\Delta\beta$ = — 9″.0

Heliocentric Coordinates.

$x = r\,[9.999991]\sin(\ 0° 31′ 50″.2 + v)$
$y = r\,[9.291988]\sin(\ 88\ 42\ 19\ .9 + v)$
$z = r\,[9.991513]\sin(270\ 36\ 12\ .2 + v)$

Ephemeris.

G.M.T. 1914	App α h m s	App. δ ° ′ ″	Log q	Light
Nov. 5.5	21 46 10.8	+ 5 32 50	0.09489	0.05
9.5	47 7.3	6 37 26	0.13237	0.04
13.5	48 31.3	7 34 39	0.16699	0.03
17.5	50 18.3	8 26 18	0.19913	0.02
21.5	52 24.4	9 13 43	0.22906	0.02
25.5	54 46.6	9 57 54	0.25701	0.02
29.5	21 57 22.0	10 39 36	0.28319	0.01
Dec. 3.5	22 0 9.0	11 19 26	0.30776	0.01
7.5	3 5.7	11 57 50	0.33089	0.01
11.5	22 6 10.9	+12 35 11	0.35269	0.01

Brightness of Oct. 1 taken as unit.

Comet Westland (1914 *e*).—The Southern comet first reported by Charles Westland of Wellington, New Zealand, on Sept. 18, 1914 was independently discovered here by myself on Sept. 20. It was then of the fourth magnitude and easily visible to the naked eye. As I have followed it since then, up to October 13, a few notes may be of interest. The chart shows its course till October 1.

It was observed each night except on September 25 (cloudy) and on the 2nd, 3rd and 4th of October (full moon).

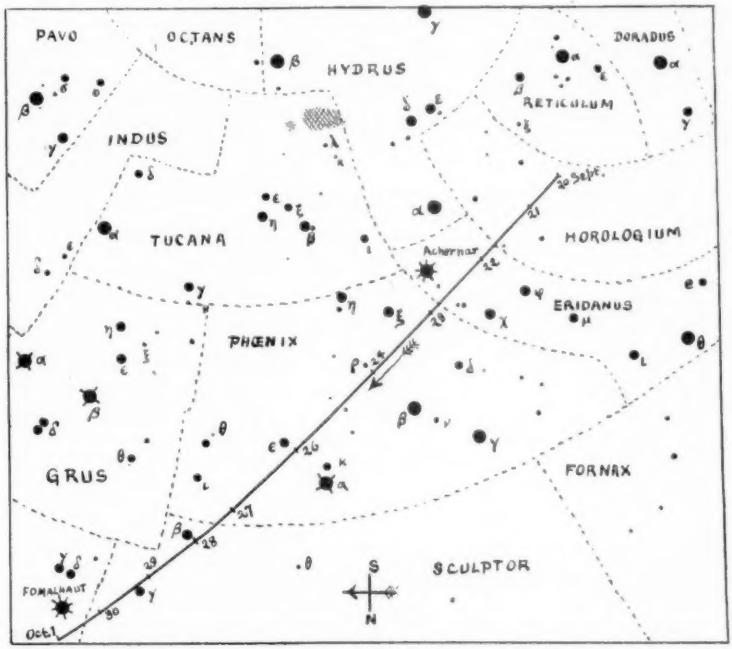


FIG. 2. CHART OF THE COURSE OF THE COMET 1914 *e* THROUGH THE SOUTHERN SKY.

Sept. 20, 7:45 p. m. While star gazing I noticed a hazy patch of light in the southern portion of Horologium which, from the absence of any nebulous object there, was at once evident as a comet. Examined with two-inch telescope and opera glass, large nebulous mass (about 15′ diameter) with central condensation (nucleus) slightly directed to side away from Achernar; no distinct tail, but suspicion of one on side away from nucleus. An hour and a half showed some movement in direction toward Achernar.

Sept. 21 and 22. On these two nights the comet was perceptibly brighter, about equal in magnitude to ϕ Eridani, mag. 3.8 or 3.7.

Sept. 23. The comet has passed Achernar to the north. Weather conditions unfavorable.

Sept. 24, 26, 27, 28. Passing through Phoenix into Sculptor.

Sept. 29, 30. In Sculptor.

Oct. 1. Seen with difficulty, owing to moonlight; estimated magnitude about 5th.

Oct. 5. Found again near 47 Aquarii, magnitude estimated 5½-6th. (Moonight).

Oct. 6. Just north of and in the same field with 53 Aquarii, the well-known double star; visible to unaided eye; mag. estimated 6.

Oct. 7 and 8. Passing between ι Aquarii and σ Aquarii, nearer former; seen with great difficulty by naked eye; estimated mag. 6-6.5.

Oct. 9 and 10. Crossed ecliptic between θ and ι Aquarii.

Oct. 11 and 12. Magnitude must be now near the 7th, as it is hard to find in either a telescope or opera glass.

Oct. 13. Last seen; estimated magnitude about 8th; very faint; like a nebula; no nucleus visible.

On Oct. 10 and 11 a short tail was detected, pointing upwards (in opera glass) or south preceding. The following elements, deduced from three observations 1914, Sept. 21, 25, 30, were kindly supplied M. Baracchi, director of Melbourne Observatory computed by his assistant Mr. Merfield. He remarks also that the comet was within twenty five million miles of us at its nearest. You will see that the comet was seen when returning from perihelion.

The elements indicate that the first approximation was a very good one.

ORBIT ELEMENTS.

Time of perihelion passage	$T = 1914$ Aug. 5.00580 G.M.T.	
Node to perihelion	$\omega = 270°\ 24'\ 43''$	1914
Longitude of Ascending Node	$\Omega = 0\ 22\ 35$	
Inclination to ecliptic	$i = 77\ 51\ 13$	
Perihelion distance	$\log q = 9.8532352$	

RESIDUALS.

$$d\lambda' \cos \beta' = -1''.8 \qquad d\beta = -3''.2$$

EQUATIONS FOR CO-ORDINATES.

$$x = [9.9999910]\ r \sin (\ 0°\ 29'\ 28''.0 + v)$$
$$y = [9.2925111]\ r \sin (\ 88\ 39\ 1\ .2 + v)$$
$$z = [9.9914928]\ r \sin (270\ 33\ 52\ .9 + v)$$

BERNARD THOMAS

Glenorchy, Tasmania, Oct. 15, 1914.

Elliptic Elements of Comet 1913 *f* (Delavan).—I have differentially corrected the orbit of Delavan's comet appearing in the June-July number of P. A., and obtained the following results. The correction was based on the following residuals:

	Observed $\cos\delta\,\Delta\alpha$	Computed $\Delta\delta$
1913 Dec. 17.6018	+ 6″.9	+ 4″.1
1914 Mar. 17.6649	+ 6 .3	+ 1 .8
Aug. 21.5000	+16 .1	−14 .0

The most probable system of elements appears to be the following:

ELLIPTIC ELEMENTS.

$T = 1914$ Oct. 26.2614 G.M.T.

$\omega = 97°\ 36'\ 38''.0$		$\omega = 97°\ 36'\ 38''.5$
$\Omega = 59\ 11\ 24\ .6$	1914.0	$\Omega = 59\ 12\ 14\ .9$ 1915.0
$i = 68\ 04\ 25\ .8$		$i = 68\ 04\ 26\ .0$

$\log e = 9.999441$
$\log q = 0.041951$

CONSTANTS FOR THE EQUATOR OF 1915.0.

$$x = r\,[9.781153]\,\sin\,(219^\circ\ 40'\ 41''.6 + v)$$
$$y = r\,[9.909301]\,\sin\,(201\ \ 25\ \ 32\ \ .7 + v)$$
$$z = r\,[9.994818]\,\sin\,(117\ \ 51\ \ 01\ \ .0 + v)$$

However, small increments of a second or so of arc assigned to the residuals will produce quite a change in all of the elements except the time of perihelion passage and Ω, which appear to be relatively determinate.

Regarding the eccentricity as constant and equal to one, a differential correction based on the three residuals in α and the last two in δ, yielded the following:

PARABOLIC ELEMENTS.

$$T = 1914\ \text{Oct.}\ 26.2464\ \text{G.M.T.}$$
$$\left.\begin{aligned}\omega &= 97^\circ\ 30'\ 01''.2\\ \Omega &= 59\ \ 12\ \ 35\ \ .2\\ i &= 68\ \ 03\ \ 01\ \ .2\end{aligned}\right\}\ 1915.0$$
$$\log q = 0.042744$$

These elements leave an outstanding residual of $+11''.3$ (O—C) in the first declination.

The inclosed ephemeris, extending from Jan. 0.5 to Feb. 13.5, is based on the elliptic orbit; but the corrections are given for the extreme dates and a middle one which will reduce it to the parabolic ephemeris. The parabola has almost as large a chance to be right as the ellipse, judging from the behaviour of previous orbits of this comet.

I might add that here in the Sierra Nevadas of California, where the air is especially clear, the comet has made quite a showing on moonless nights. At one time it was about $3^m.5$ and later it had a tail distinctly visible for a distance of five or six degrees and faintly for three or four more. On one or two occasions there was a suspicion of a fainter fan-like tail preceding and making an angle of 30° or 35° with the main tail. The comet will begin to emerge from the sun in the morning about January 1.

EPHEMERIS OF COMET DELAVAN (1913 *f*).

For Greenwich Mean Midnight.

Date	True α	True δ	log r	log Δ	Br.
	h m s	° ′ ″			
1914 Dec. 31.5	16 43 37.7	−10 36 34.9			
1915 Jan. 4.5	49 41.0	12 05 19.0	0.19421	0.36186	17.3
8:5	16 55 29.7	13 31 06.2			
12.5	17 01 06.7	14·54 19.0	0.21741	0.36700	15.2
16.5	06 30.5	16 15 28.6			
20.5	11 41.3	17 34 40.0	0.24017	0.37014	13.4
24.5	16 39.4	18 51 59.4			
Jan. 28.5	21 23.7	20 07 58.9	0.26205	0.37097	12.1
Feb. 1.5	25 53.9	21 23 06.4			
5.5	30 09.2	22 37 40.0	0.28315	0.36988	11.0
9.5	34 09.0	23 52 02.8			
13.5	17 37 52.6	−25 06 25.8	0.30351	0.36710	10.2

Correction to be applied to above elliptic ephemeris to reduce to parabolic.

	$\Delta\alpha$	$\Delta\delta$
Dec. 31.5	− 8ˢ.2	+ 8′ 33″.4
Jan. 20.5	−11 .6	+ 9 55 .5
Feb. 13.5	−17 .9	+10 52 .0

Brightness on date of discovery, 1913 Dec. 17 = 1.

MAXWELL W. ALLEN.

Grub Gulch, California, Oct. 28, 1914.

Delavan's Comet.—An ephemeris of Delavan's Comet, of which the following is a condensed extract, was received by mail from M. G. Van Biesbroeck, of the Royal Observatory, Uccle, Belgium, with the following comment:—"Computed during the anxious days of war, taken over to London by a friend leaving this unhappy country via the Hague."

			12^h α vera h m s	M.T. Berlin δ vera ° ′	log r	log Δ	Magn.
1914	Nov.	15	15 14 14	+12 12.0	0.06154	0.27546	4.9
		23	33 28	7 18.2	0.07755	0.29485	5.0
	Dec.	1	50 39	+ 2 52.6	0.09692	0.31255	5.2
		9	16 6 17	— 1 7.8	0.11854	0.32809	5.4
		17	20 40	4 45.9	0.14149	0.34123	5.6
		25	34 2	8 5.2	0.16504	0.35190	5.8
1915	Jan.	2	46 29	11 9.0	0.18865	0.36011	5.9
		10	58 5	14 0.2	0.21197	0.36595	6.1
		18	17 8 52	16 41.7	0.23474	0.36950	6.2
		26	18 46	19 16.3	0.25682	0.37088	6.3
	Feb.	3	27 44	21 46.4	0.27813	0.37029	6.4
		11	35 41	24 14.5	0.29864	0.36788	6.5
		19	42 29	26 42.7	0.31833	0.36388	6.6
		27	47 56	29 13.1	0.33732	0.35858	6.7
	Mar.	7	51 51	31 47,3	0.35534	0.35233	6.7
		15	53 58	−34 26.3	0.37371	0.34553	6.8

Ephemeris from elements *A.N.* 4739.
Correction for 1914, October 1, $+2^s$, $+0''.7$.
Magnitude nearly 2^m brighter.

EDWARD C. PICKERING

Harvard College Observatory, Bulletin 571.
Cambridge, Mass. Nov. 9, 1914.

NOTES FOR OBSERVERS.

Monthly Report of the American Association of Variable Star Observers, Oct.-Nov., 1914.

Interest in the work of variable star observing continues unabated as the copious lists of estimates sent in this month bear testimony.

Mr. Charles F. Richter of Los Angeles, Cal., has broken the individual record for a month's work, heretofore held by Mr. Bancroft, by contributing this month 490 observations of forty variables, a record greatly to his credit, and which is highly indicative of his zeal and interest. Mr. Richter joined the Association in November 1913, and the results he has achieved in this line of work in this comparatively short time show what diligence and earnest effort can accomplish.

We welcome as a new member of the Association Mr. William Herriott, "He" of Pittsburgh, Pa., who observes with a 5½″ Brashear reflector.

Thanks are due Mr. Charles B. Lindsley and David B. Pickering for carefully executed blue prints of the charts for distribution,

It is a pleasure to note that Mr. Campbell's plan for a systematic search for novae has met with favor, and many have undertaken to observe the zones. It is hoped that more observers will coöperate in this practical plan, and that the remaining zones will soon be under observation.

VARIABLE STAR OBSERVATIONS Oct.-Nov. 1914.

001726
T Androm.

Mo.	Day	Est	Obs.
10	22	12.3	Y

001755
T Cassiop.

Mo.	Day	Est	Obs.
10	4	8.6	Bu
	5	8.5	B
	9	10.0	R
	11	9.9	R
	11	8.1	Sp
	12	9.0	S
	12	9.4	Bl
	12	9.9	R
	13	9.8	R
	14	9.8	R
	15	9.7	R
	16	9.5	R
	19	9.3	O
	20	8.0	Bu
	21	8.2	Sp
	22	8.8	R
	22	8.5	Sp
	23	8.9	R

001838
R Androm.

Mo.	Day	Est	Obs.
10	20	10.9	Hu

001909
S Ceti

Mo.	Day	Est	Obs.
9	27	9.0	R
10	9	10.0	R
	10	10.5	R
	11	10.4	R
	12	10.6	Bl
	12	10.6	R
	19	10.8	S
	20	10.9	Y
	22	10.6	R
	23	10.7	R

003179
Y Cephei

Mo.	Day	Est	Obs.
10	22	12.0	Hu

004435
V Androm.

Mo.	Day	Est	Obs.
10	20	12.6	Hu

004533
RR Androm.

Mo.	Day	Est	Obs.
10	4	10.8	Bu
	18	10.6	O
	20	10.5	Bu
	20	9.6	Hu
	21	10.5	O
	23	10.5	O
	27	10.4	O

004746
RV Cassiop.

Mo.	Day	Est	Obs.
10	1	11.7	L
	9	10.6	L

004958
W Cassiop.

Mo.	Day	Est	Obs.
10	5	10.4	B
	11	11.9	Sp
	21	11.2	Sp
	23	11.2	Sp

011272
S Cassiop.

Mo.	Day	Est	Obs.
10	7	12.6	Ly

011208
S Piscium

Mo.	Day	Est	Obs.
10	12	11.4	Bl
	20	11.1	Y
	22	10.3	O

012502
R Piscium

Mo.	Day	Est	Obs.
10	12	10.5	S
	20	9.8	Y
	22	9.1	O

013338
Y Androm.

Mo.	Day	Est	Obs.
10	15	9.8	R
	16	9.8	R

014958
X Cassiop.

Mo.	Day	Est	Obs.
10	4	10.6	Bu
	9	11.6	L
	10	10.5	M
	20	10.8	Bu
	23	10.0	Y

015354
U Persei

Mo.	Day	Est	Obs.
10	7	10.9	Ly
	12	10.5	Bl
	18	10.7	Ly
	19	10.1	Pi
	27	9.7	Pi

021024
R Arietis

Mo.	Day	Est	Obs.
10	4	8.0	Bu
	11	8.4	Ly
	11	8.8	Ma
	12	9.4	S
	12	9.1	Bl
	13	9.9	R
	14	9.3	R
	15	9.3	R
	16	9.5	R
	18	9.5	O
	19	8.6	Ly
	19	9.5	S
	19	9.4	Pi
	20	9.4	Ma
	20	9.5	O

R Arietis

Mo.	Day	Est	Obs.
10	20	8.2	Bu
	21	9.3	R
	22	9.8	R
	23	9.8	R
	25	10.0	Hy
	27	9.9	Pi

021143
W Androm.

Mo.	Day	Est	Obs.
10	20	12.6	Y

021403
o Ceti

Mo.	Day	Est	Obs.
9	24	9.1	L
	29	8.9	L
10	4	8.6	Bu
	11	9.0	C
	12	9.1	Bl
	14	8.9	C
	15	8.9	R
	15	9.1	C
	17	9.0	Pi
	28	8.6	Bu
	22	8.9	R

021658
S Persei

Mo.	Day	Est	Obs.
10	8	11.8	Ly
	11	12.0	Sp
	11	11.7	Ly
	18	11.8	Ly
	22	11.8	Sp

022000
R Ceti

Mo.	Day	Est	Obs.
10	20	10.6	Y

022150
RR Persei

Mo.	Day	Est	Obs.
10	22	11.5	Y

022813
U Ceti

Mo.	Day	Est	Obs.
9	24	11.0	L

023133
R Triang.

Mo.	Day	Est	Obs.
10	4	7.2	Bu
	18	7.1	O
	20	7.4	Bu
	21	7.1	O
	21	8.0	Hu
	22	7.0	Pi
11	5	8.0	O

024356
W Persei

Mo.	Day	Est	Obs.
9	27	9.5	R
10	1	9.5	R
	6	10.0	Ly
	7	9.4	R
	9	9.6	L
	9	9.6	R

W Persei

Mo.	Day	Est	Obs.
10	10	10.3	M
	10	9.5	R
	11	10.0	Ly
	11	9.4	R
	12	9.4	R
	12	9.3	Hy
	12	10.4	Bl
	13	9.5	R
	14	9.4	R
	15	9.5	R
	16	9.5	R
	18	10.4	O
	19	10.1	Ly
	19	10.2	Pi
	21	9.5	R
	21	9.6	Hu
	22	9.4	R
	22	9.2	Hy
	23	9.3	R
	23	9.2	Hy
	25	10.0	Hy
	27	10.2	Pi

032043
Y Persei

Mo.	Day	Est	Obs.
	6	10.1	Ly
	10	10.6	M
	10	10.0	R
	11	10.0	Ly
	11	10.1	R
	12	10.2	Bl
	12	10.1	R
	13	9.9	R
	14	9.8	R
	15	9.8	R
	16	10.1	R
	19	10.1	Ly
	20	10.2	E
	21	9.9	R
	21	9.2	Hu
	22	10.2	R
	23	10.3	R
	27	9.8	Ma

032335
R Persei

Mo.	Day	Est	Obs.
10	22	12.5	Y

033362
U Camelop.

Mo.	Day	Est	Obs.
10	6	7.8	Ly
	11	7.8	Ly
	16	7.7	Ly
	27	7.6	Ma

042215
W Tauri

Mo.	Day	Est	Obs.
10	9	8.9	M
	12	8.8	B
	21	9.5	Pi
	27	10.0	Pi

043274
X Camelop.

Mo.	Day	Est	Obs.
9	29	8.7	L
10	7	8.8	Ly
	12	9.8	Bl
	12	9.7	Ly
	13	10.3	L
	16	10.2	Ly
	18	10.4	O
	19	10.8	Pi
	21	11.0	Pi
	22	11.0	Sp
	23	11.1	O
	23	11.3	Y

045514
R Leporis

Mo.	Day	Est	Obs.
9	24	7.0	L
10	1	6.4	L
	13	6.2	L

050953
R Aurigae

Mo.	Day	Est	Obs.
10	12	8.5	Bg
	21	11.5	Pi
	21	11.3	Pi

052034
S Aurigæ

Mo.	Day	Est	Obs.
10	23	8.8	Y
	31	9.6	M

053005
T Orionis

Mo.	Day	Est	Obs.
10	12	9.5	M

054319
SU Tauri

Mo.	Day	Est	Obs.
10	23	9.7	Y

054920
U Orionis

Mo.	Day	Est	Obs.
10	3	9.2	L
	27	10.2	Pi

060450
X Aurigae

Mo.	Day	Est	Obs.
9	24	10.7	L
10	21	10.0	Pi

064922
Nova Gemin.

Mo.	Day	Est	Obs.
9	29	11.7	L

065208
X Monoc.

Mo.	Day	Est	Obs.
10	13	9.4	L

070122a
R Gemin.

Mo.	Day	Est	Obs.
10	17	8.0	Pi

070310
R Can. Min.

Mo.	Day	Est	Obs.
10	1	8.4	L

VARIABLE STAR OBSERVATIONS Oct.-Nov., 1914.—Continued.

072708
S Can. Min.

Mo.	Day	Est.	Obs.
9	24	10.8	L
10	1	10.6	L
	9	10.0	Ly
	16	9.7	Ly
	17	9.3	Pi

073508
U Can. Min.

Mo.	Day	Est.	Obs.
10	1	10.4	L

081112
R Cancri

Mo.	Day	Est.	Obs.
9	24	10.2	L

082405
RT Hydrae

Mo.	Day	Est.	Obs.
9	24	8.0	L
10	3	8.1	L

085120
T Cancri

Mo.	Day	Est.	Obs.
9	24	9.2	L

090425
W Cancri

Mo.	Day	Est.	Obs.
9	29	11.8	L

094211
R Leonis

Mo.	Day	Est.	Obs.
9	24	9.6	L
10	7	9.1	Ly
	13	9.1	L
	22	8.6	Sp

123961
S Urs. Maj.

Mo.	Day	Est.	Obs.
9	24	8.2	L
10	4	8.5	M
	6	8.0	Ly
	8	8.3	M
	10	8.3	Bl
	11	8.5	Bg
	11	7.8	C
	12	8.7	L
	12	8.1	Ly
	15	8.0	C
	16	7.9	Ly
	22	8.4	Sp
	22	8.0	M
	25	7.8	M

134440
R Can. Ven.

Mo.	Day	Est.	Obs.
10	6	12.0	Ly
	30	11.0	M

141954
S Boötis

Mo.	Day	Est.	Obs.
10	5	11.0	L
	6	11.1	Ly
	7	11.0	H
	12	01.9	Ly
	13	10.2	Bg
	16	10.4	H

142539
V Boötis

Mo.	Day	Est.	Obs.
9	27	10.0	R
10	4	9.6	M
	5	10.3	L
	7	10.1	Ly
	7	9.8	H
	10	8.8	Bg
	10	11.2	R
	11	10.6	R
	12	11.2	R
	13	11.3	R
	16	9.9	H
	19	9.9	H
	25	9.7	M

142584
R Camelop.

Mo.	Day	Est.	Obs.
9	29	9.0	L
10	7	9.1	Ly
	9	9.0	L
	11	9.0	O
	12	8.9	Ly
	18	9.0	O
	20	8.7	Ly
	20	8.6	B
	20	8.9	O
	23	8.8	O
	27	8.7	O
11	5	8.5	O

143227
R Boötis

Mo.	Day	Est.	Obs.
9	27	8.6	R
	5	8.8	L
9	7	8.8	R
	8	8.8	Ly
	9	8.9	R
	18	8.8	Bl
	11	9.4	Bg
	11	9.2	R
	11	9.0	Ly
	12	9.3	R
	14	9.2	R
	25	9.4	M

151432
U Cor. Bor.

Mo.	Day	Est.	Obs.
10	16	8.1	H
	19	7.8	H

151714
S Serpentis

Mo.	Day	Est.	Obs.
9	30	10.3	L
10	9	10.2	L

151731
S Cor. Bor.

Mo.	Day	Est.	Obs.
10	7	12.5	H
	16	12.1	H
	19	11.0	H
	25	11.3	M

153378
S Urs. Min.

Mo.	Day	Est.	Obs.
9	29	8.8	L
10	3	8.8	B
	7	9.2	Ly
	9	9.0	L
	10	8.6	Bg
	12	9.4	Ly
	20	9.8	Ly
	21	9.8	O
	22	10.0	Pi

154428
R Cor. Bor.

Mo.	Day	Est.	Obs.
9	26.7	6.1	R
	27.6	6.0	R
	30	6.0	L
10	1	5.9	H
	1.6	6.1	R
	3	5.7	H
	4.4	6.0	Bu
	5.6	6.3	R
	6	6.1	Ma
	6	5.9	Ly
	6.7	6.3	R
	7.6	6.3	R
	7	5.9	H
	8	5.9	H
	8	6.0	Ma
	9	6.0	L
	9.6	6.2	R
	9.5	6.1	Bl
	10.6	5.9	Bg
	10.5	6.0	Bl
	10.6	6.2	R
	11.6	6.0	C
	11.6	6.2	R
	11.6	6.3	Mu
	11.4	6.0	O
	11.5	5.8	J
	11	6.0	Ly
	12.5	6.0	Bl
	12.6	6.4	Mu
	12.6	6.3	R
	13.6	6.4	Mu
	13.6	6.1	R
	14	6.0	Ly
	14	6.0	H
	14.6	6.2	R
	14.6	6.1	C
	15.6	6.3	R
	15.6	6.0	C
	16	6.1	Ly
	16	6.0	Ma
	16	6.0	H
	16.6	6.2	R
	18.4	6.0	O
	19	6.0	Ly
	19	6.0	Ma
	19	6.1	H
	19.4	6.0	O
	19.5	6.0	Bl

R Cor. Bor.

Mo.	Day	Est.	Obs.
10	19.5	6.5	E
	20	6.4	Ph
	20.4	6.0	O
	20.6	6.4	Mu
	21	6.0	Ly
	21.6	6.5	Mu
	21.4	6.0	O
	22.5	6.0	Pi
	22.5	6.0	J
	22.4	6.0	O
	22.6	6.3	R
	23.4	6.0	O
	23.6	6.2	R
	25.5	6.0	M
	25.6	5.8	Bg
	27.4	6.0	O

154539
V Cor. Bor.

Mo.	Day	Est.	Obs.
10	4	10.5	Bu
	7	10.9	Ly
	12	11.0	Ly
	16	10.0	H

155947
X Herculis

Mo.	Day	Est.	Obs.
9	26	5.8	R
	27	5.8	R
10	1	5.9	H
	3	6.0	H
	7	6.1	L
	7	6.2	H
	11	5.7	R
	12	6.2	R
	12	5.6	R
	13	5.6	R
	14	5.6	R
	14	6.4	H
	15	5.6	R
	16	5.5	R
	16	6.4	H
	19	6.4	H
	22	5.8	R

160118
R Herculis

Mo.	Day	Est.	Obs.
10	7	12.3	H

160210
U Serpentis

Mo.	Day	Est.	Obs.
10	4	10.0	Bu
	7	10.2	Ly
	16	10.0	Ly

160625
RU Herculis

Mo.	Day	Est.	Obs.
10	22	13.3	B

161138
W Cor. Bor.

Mo.	Day	Est.	Obs.
10	5	9.4	Bu
	19	11.0	H
	22	11.1	B

162112
V Ophiuchi

Mo.	Day	Est.	Obs.
10	7	8.7	Ly

162119
U Herculis

Mo.	Day	Est.	Obs.
10	6	11.8	Ly
	16	11.7	Ly
	16	11.5	H
	19	11.3	H
	21	11.3	Y
	24	11.9	Ly

162807
SS Herculis

Mo.	Day	Est.	Obs.
10	5	10.1	L

163137
W Herculis

Mo.	Day	Est.	Obs.
10	5	8.0	Bu
	11	8.1	O
	11	8.1	C
	12	8.2	S
	14	8.0	C
	18	8.1	O
	19	8.0	Hu
	20	8.2	O
	21	8.3	Y
	22	8.2	B
	23	8.2	O
	25	8.4	M
	27	8.4	O

163172
R Urs. Min.

Mo.	Day	Est.	Obs.
9	26	9.4	R
	27	9.5	R
10	1	9.4	R
	5	9.4	Bu
	7	9.5	R
	9	9.3	Ly
	9	9.4	R
	10	9.3	Bg
	10	9.5	R
	10	9.5	B
	11	9.4	R
	12	9.4	R
	13	9.4	R
	14	9.4	R
	15	9.4	R
	16	9.4	R
	20	9.4	Bu
	20	9.4	Ly
	22	9.4	R
	23	9.4	L
	24	9.4	Ly
	25	9.7	M

VARIABLE STAR OBSERVATIONS Oct.-Nov., 1914.—Continued.

163266
R Draconis

Mo.	Day	Est.	Obs.
10	5	10.5	Bu
	6	10.6	Ly
	7	10.0	M
	10	10.2	Bl
	11	9.6	Sp
	12	10.0	Ly
	17	8.5	Ma
	19	9.8	S
	19	9.3	A
	20	9.8	Bu
	20	9.4	Ly
	21	9.2	E
	23	8.5	R
	24	9.3	Ly
	25	9.9	M
	27	8.6	Ma

164055
S Draconis

Mo.	Day	Est.	Obs.
10	10	8.4	M
	22	8.5	M
	25	8.6	M
	31	8.7	M

164715
S Herculis

Mo.	Day	Est.	Obs.
9	27	9.2	R
10	1	9.1	R
	5	9.5	Bu
	6	9.2	Ly
	7	9.3	R
	8	9.1	Ma
	9	9.0	R
	9	10.3	H
	10	9.4	Bl
	10	10.7	R
	11	9.5	Ly
	11	10.9	R
	12	10.2	R
	13	10.1	R
	14	10.1	C
	14	10.3	R
	15	10.3	R
	16	10.2	R
	18	10.1	O
	18	9.8	Ly
	21	10.0	Ly
	22	9.3	B
	22	10.4	R
	23	10.3	R
	24	10.1	Ly

165631
RV Herculis

Mo.	Day	Est.	Obs.
10	7	13.9	M
	11	13.8	M
	19	19.7	H

170215
R Ophiuchi

Mo.	Day	Est.	Obs.
10	5	8.5	L
	9	8.4	Ly
	10	9.0	Bl
	13	8.8	L

171333
u Herculis

Mo.	Day	Est.	Obs.
9	26	4.7	R
	27	5.1	R
10	1	4.8	R
	5	5.1	R
	6	5.1	R
	7	5.0	R
	9	4.7	R
	10	5.1	R
	11	5.1	R
	12	4.6	R
	13	4.3	R
	14	5.0	R
	15	4.4	R
	16	5.1	R
	17	4.7	R
	18	5.0	R
	22	4.5	R
	23	5.1	R

171723
RS Herculis

Mo.	Day	Est.	Obs.
9	30	9.5	L
10	9	10.1	L

172808
RU Ophiuchi

Mo.	Day	Est.	Obs.
10	5	9.8	B
	11	9.6	V
	19	9.6	V
	25	9.8	M

175458
T Draconis

Mo.	Day	Est.	Obs.
9	26	9.6	R
	27	9.3	R
10	5	10.4	Bu
	7	9.7	R
	9	9.4	R
	10	9.6	R
	11	10.7	V
	11	9.6	R
	11	9.9	Sp
	12	9.6	R
	13	9.6	R
	14	9.4	R
	15	9.7	R
	16	9.6	R
	20	10.8	Bu
	21	10.7	V
	21	10.4	O
	22	9.6	R
	23	9.7	R

175519
RY Herculis

Mo.	Day	Est.	Obs.
10	11	9.1	O
	18	9.0	O
	20	9.2	O
	22	9.3	Y
	22	9.0	R
	27	9.0	O
10	6	9.3	O

180531
T Herculis

Mo.	Day	Est.	Obs.
9	27	8.3	R
10	1	8.2	R
	5	8.4	L
	5	8.4	Bu
	5	8.3	R
	6	8.4	Ma
	7	8.2	R
	7	8.0	H
	8	8.6	H
	9	8.3	R
	10	8.3	R
	10	8.5	Bl
	11	8.8	Ly
	11	8.7	O
	11	8.3	R
	11	8.5	C
	12	8.4	R
	12	8.6	S
	13	8.2	R
	14	8.3	C
	14	8.3	R
	15	8.6	C
	15	8.2	R
	16	8.4	R
	16	8.9	Ma
	18	9.1	Ly
	18	8.7	O
	19	9.0	Ph
	19	8.9	Hu
	19	9.1	H
	20	7.8	Bu
	20	9.0	O
	20	8.9	Ma
	21	9.3	Ly
	21	8.9	E
	22	8.4	R
	23	9.2	O
	23	8.5	R
	27	9.3	O

181136
W Lyrae

Mo.	Day	Est.	Obs.
9	27	12.2	R
10	1	10.2	R
	2	11.1	B
	4	10.7	M
	7	10.3	R
	8	11.0	M
	9	12.5	H
	10	10.9	R
	11	10.7	R
	13	10.7	R

W Lyrae

Mo.	Day	Est.	Obs.
10	14	10.8	R
	15	10.8	R
	16	10.8	R
	19	12.2	H
	19	11.3	Hu
	22	11.2	M
	22	11.0	R
	23	11.1	R

182224
SV Herculis

Mo.	Day	Est.	Obs.
10	22	12.5	B

182619
U Sagittarii

Mo.	Day	Est.	Obs.
10	11	7.1	C
	14	6.8	C
	15	6.9	C

183308
X Ophiuchi

Mo.	Day	Est.	Obs.
10	5	7.0	Bu
	6	7.2	Ly
	7	6.8	L
	10	7.0	Bl
	11	7.3	Ly
	11	6.9	C
	14	6.9	C
	15	6.7	C
	17	6.5	Ma
	18	7.0	Ly
	19	6.5	Ma
	19	7.3	H
	19	6.8	V
	20	6.7	Ma
	21	6.9	E
	21	6.9	Ly
	24	6.7	Ly
	27	6.3	Ma

184205
R Scuti

Mo.	Day	Est.	Obs.
10	1	5.3	H
	1.6	5.6	R
	3	5.1	H
	5	5.4	L
	5.5	5.5	Bu
	5.6	5.6	R
	6.7	5.7	R
	6	5.6	Ma
	7	5.4	H
	7.6	5.8	R
	8	5.4	Ly
	8	5.3	H
	8	5.6	Ma
	9.6	6.0	Hy
	9.6	5.7	R
	9.5	5.6	Bl
	10	5.4	Ly
	10.6	5.7	R
	10.5	5.7	Bl
	11.6	5.5	C

R Scuti

Mo.	Day	Est.	Obs.
10	11.4	5.5	O
	11.6	5.7	R
	12.5	5.6	Hy
	12.5	5.6	O
	12.5	5.6	Bl
	12.6	5.6	R
	13.6	5.7	R
	13	5.2	L
	14	5.5	Ly
	14	5.3	H
	14.6	5.6	C
	14.6	5.6	R
	15.6	5.6	C
	15.6	5.7	R
	16	5.0	H
	16	5.4	Ly
	16.6	5.8	R
	16	5.7	Ma
	18.4	5.5	O
	18.6	5.7	R
	19.5	5.6	Bl
	19	4.9	H
	19	5.7	Ma
	19.5	5.5	Pi
	19	5.5	Ly
	20.4	5.5	O
	21	5.8	Ma
	21.4	5.6	O
	21	5.6	Ly
	22.5	5.5	Pi
	22.4	5.5	O
	22.6	5.9	R
	22.6	5.7	Hy
	23.4	5.5	O
	23.6	5.9	R
	23.6	5.7	Hy
	24	5.6	Ly
	25.6	5.8	M
	26	5.7	Ly
	27.4	5.7	O
	27	5.8	My
11	5.5	5.7	O
	6.4	5.7	O

184633
β Lyrae

Mo.	Day	Est.	Obs.
9	26.6	3.9	R
	27.6	4.0	R
	29.6	3.7	R
10	1.6	3.6	R
	4.6	3.7	R
	5.6	3.6	R
	6.7	3.6	R
	7.6	3.4	R
	8.7	3.7	R
	9.6	4.4	R
	10.6	4.2	R
	11.6	3.7	R
	12.6	3.4	R
	13.7	3.4	R
	14.6	3.4	R

VARIABLE STAR OBSERVATIONS Oct.-Nov., 1914—Continued.

β Lyrae

Mo.	Day	Est.	Obs.
10	15.6	3.5	R
	16.6	3.7	R
	17.6	3.7	R
	18.7	3.6	R
	21.7	3.7	R
	22.6	3.8	R
	23.6	4.1	R

185243

R Lyrae

9	26	4.1	R
	27	4.2	R
10	1	4.2	R
	5	3.9	R
	6	4.4	R
	7	4.2	R
	9	4.4	R
	10	4.4	R
	11	4.2	R
	12	4.1	R
	13	3.9	R
	14	3.9	R
	15	4.1	R
	16	3.9	R
	17	4.3	R
	18	4.2	R
	22	5.0	R
	23	4.8	R

190108

R Aquilae

10	3	7.1	B
	5	6.9	L
	5	8.0	Bu
	10	7.0	Bl
	19	6.0	E
	22	6.5	O
	22	6.5	B

190967

U Draconis

10	22	12.1	Hu

190926

X Lyrae

10	5	9.0	Bu
	8	8.7	Ly
	9	9.7	R
	10	8.6	R
	10	9.0	Bl
	11	8.6	Ly
	11	9.0	C
	12	9.1	R
	13	9.1	R
	14	8.8	C
	14	9.2	R
	15	8.9	C
	15	9.2	R
	16	9.3	R
	20	9.2	Ba

X Lyrae

Mo.	Day	Est.	Obs.
10	20	9.2	E
	21	8.9	O
	21	9.0	Ly
	22	9.3	R
	23	9.2	R
	25	8.3	M

191033

RY Sagittarii

10	7	7.2	R
	7	7.4	H
	9	6.9	H
	10	7.2	R
	11	6.9	C
	11	7.2	R
	12	7.6	R
	13	7.2	R
	14	7.3	H
	14	7.1	C
	14	7.1	R
	15	7.2	R
	15	7.0	R
	16	7.0	H
	16	7.1	R
	22	7.2	R

193311

RT Aquilae

10	4	10.0	Bu
	9	10.3	L
	11	10.4	O
	18	10.7	O
	20	10.6	Bu
	22	10.6	O

193449

R Cygni

9	29	12.2	L
10	7	12.1	M
	11	12.2	M
	20	12.0	Ly

193732

TT Cygni

9	26	8.4	R
	27	8.4	R
10	1	8.4	R
	4	7.8	Bu
	5	8.4	R
	6	8.5	R
	7	8.4	R
	7	7.8	Ly
	9	8.4	R
	9	8.0	Bl
	10	8.4	R
	10	7.7	Ma
	10	7.5	M
	11	8.3	R
	11	7.9	C
	12	7.7	Ly
	12	8.3	R

TT Cygni

Mo.	Day	Est.	Obs.
10	14	8.0	C
	14	8.4	R
	15	8.3	R
	15	7.9	C
	16	8.5	R
	17	7.8	Ma
	18	7.8	Ly
	19	8.0	Bl
	19	8.5	Hu
	20	7.8	Bu
	21	7.9	Ma
	21	8.0	E
	21	8.5	R
	22	8.5	R
	23	8.5	R
	24	7.7	Ly
	25	7.4	Hy
	25	8.0	M

194048

RT Cygni

9	26	8.2	R
	27	8.1	R
	29	7.5	L
10	1	8.2	R
	4	8.0	Bu
	5	8.2	R
	6	8.2	R
	7	8.2	R
	8	7.6	Ma
	9	8.0	M
	9	8.3	R
	10	8.3	R
	10	8.3	Bl
	11	8.3	R
	12	7.8	Ly
	12	8.3	R
	12	8.2	S
	13	8.2	R
	14	8.2	R
	15	8.3	R
	16	8.3	R
	18	8.3	O
	19	7.9	Hu
	19	7.9	Ma
	20	7.6	Bu
	20	7.8	Ly
	21	8.2	R
	21	8.3	O
	22	8.2	R
	22	8.2	M
	23	8.4	R
	24	7.6	Ly
	27	7.7	Ma
	31	8.4	M
11	5	8.5	O

194348

TU Cygni

9	26	9.5	R
	27	9.4	R

TU Cygni

Mo.	Day	Est.	Obs.
9	29	10.7	L
10	1	9.5	R
	4	10.6	Bu
	5	9.6	R
	6	9.7	R
	7	9.7	R
	9	9.6	R
	9	10.7	Ly
	10	9.6	R
	10	11.0	M
	11	9.6	R
	11	11.1	M
	12	9.6	R
	13	9.6	R
	14	9.6	R
	15	9.7	R
	16	9.8	R
	19	11.3	Hu
	20	11.1	Ly
	21	9.6	R

194604

X Aquilae

10	22	13.4	B

194632

χ Cygni

9	26	8.3	R
	27	8.2	R
10	1	8.5	R
	4	7.2	Bu
	5	8.2	R
	5	7.3	L
	6	8.3	R
	6	7.6	Ma
	7	7.6	Ly
	7	8.2	R
	9	8.1	R
	9	7.6	Bl
	10	7.5	M
	10	7.3	Ma
	10	8.1	R
	11	7.4	Le
	11	7.4	Bg
	11	8.1	R
	12	7.6	Ly
	12	8.0	R
	13	7.7	R
	14	7.6	R
	15	7.4	R
	16	7.7	R
	17	7.0	Ma
	18	7.1	O
	18	7.5	Ly
	19	7.0	Bl
	19	7.3	E
	19	7.3	Hu
	20	6.8	Bu
	20	7.4	O
	21	7.3	R
	21	7.3	O

χ Cygni

Mo.	Day	Est.	Obs.
10	22	6.9	M
	22	7.4	R
	22	7.0	O
	23	6.4	Hy
	23	7.0	O
	23	7.2	R
	24	7.3	Ly
	25	6.8	M
	25	6.3	Hy
	27	7.5	O
	27	6.6	Ma
	31	6.5	M
11	5	6.1	O

194700

η Aquilae

9	26.7	4.1	R
	27.6	4.1	R
10	1.6	4.1	R
	5.6	4.0	R
	6.6	4.3	R
	7.6	4.6	R
	9.6	4.3	R
	10.6	4.1	R
	11.6	4.0	R
	12.6	4.2	R
	13.6	4.2	R
	14.6	4.4	R
	15.6	4.5	R
	16.6	4.5	R
	17.6	4.8	R
	18.7	4:2	R
	21.7	4.1	R
	22.6	4.5	R
	23.6	4.5	R

195116

S Sagittae

9	26.7	5.8	R
	26.7	6.2	R
10	1.6	5.5	R
	4.5	5.8	Bu
	5.6	6.2	R
	6.7	6.2	R
	7.6	5.8	R
	9.7	5.6	R
	10.6	5.5	Mu
	10.6	5.6	R
	11.6	5.2	C
	11.6	5.5	Mu
	11.4	5.4	O
	11.6	5.5	R
	12.5	5.6	O
	12.6	5.6	Mu
	12.6	5.6	R
	13.6	5.9	R
	13.6	5.7	Mu
	14.6	5.7	C
	14.6	5.8	R
	15.6	6.2	R

VARIABLE STAR OBSERVATIONS Oct.-Nov., 1914.—Continued.

S Sagittae			
Mo.	Day	Est.	Obs.
10	15.6	6.0	C
	16.6	6.2	R
	17.7	5.7	Mu
	17.6	5.7	R
	18.7	5.9	R
	18.5	5.4	O
	19.4	5.4	O
	20.6	5.4	Mu
	20.4	5.4	O
	20.5	5.8	Bu
	21.6	5.5	Mu
	21.4	5.7	O
	21.7	5.7	R
	22.4	5.8	O
	22.6	5.6	R
	23.4	5.9	O
	23.6	5.8	R
	27.4	5.4	O
11	5.5	5.4	O
	6.4	5.4	O

195202

RR Aquilae

Mo.	Day	Est.	Obs.
10	19	9.4	H

195849

Z Cygni

Mo.	Day	Est.	Obs.
10	6	11.1	Ly
	9	11.2	Ly
	10	12.6	M
	11	12.0	Sp
	18	11.7	Ly
	20	11.8	Ly
	24	11.9	Ly

200212

SY Aquilae

Mo.	Day	Est.	Obs.
10	19	12.2	H

200647

SV Cygni

Mo.	Day	Est.	Obs.
9	26	9.5	R
	27	9.5	R
10	1	9.4	R
	4	8.2	Bu
	5	9.4	R
	6	9.2	Ly
	6	9.4	R
	7	9.4	R
	9	9.3	M
	9	9.4	R
	10	9.1	Ma
	10	9.4	R
	10	9.5	Bl
	11	9.2	C
	11	9.5	R
	11	8.9	Le
	12	9.3	Ly
	12	9.5	R
	13	9.6	R
	14	9.2	C

SV Cygni

Mo.	Day	Est.	Obs.
10	14	9.6	R
	15	9.3	C
	15	9.6	R
	16	9.6	R
	18	9.3	Ly
	19	7.8	Hu
	20	8.4	Bu
	20	9.4	Ma
	21	9.7	E
	21	9.5	R
	22	9.5	R
	22	8.6	Hy
	23	9.4	R
	23	8.6	Hy
	25	7.7	Hy
	31	9.3	M

200715a

S Aquilae

Mo.	Day	Est.	Obs.
9	27	9.6	R
10	1	9.5	R
	4	9.2	Bu
	5	9.4	R
	6	9.6	R
	7	9.5	R
	9	9 4	R
	10	9.3	R
	11	9.5	R
	12	9.5	R
	13	9.5	R
	14	9.5	R
	15	9.3	R
	16	9.3	R
	20	9.6	R
	21	9.4	R
	22	9.3	R
	23	9.5	R

200715b

RW Aquilae

Mo.	Day	Est.	Obs.
10	4	8.8	Bu
	5	9.0	R
	6	9.0	R
	7	8.9	R
	9	8.9	R
	10	8.9	R
	11	8.9	R
	12	8.9	R
	13	8.9	R
	14	8.9	R
	15	8.8	R
	15	9.0	R
	16	8.8	R
	20	8.2	Bu
	21	8.9	R
	22	9.0	R
	22	8.8	R
	23	8.9	R

200906

Z Aquilae

Mo.	Day	Est.	Obs.
10	20	10.2	B

200916

R Sagittae

Mo.	Day	Est.	Obs.
9	26	9.1	R
	27	9.1	R
10	1	9.1	R
	5	9.3	R
	6	9.1	R
	7	9.2	R
	9	9.3	R
	10	9.2	R
	11	9.2	R
	12	9.1	R
	13	9.1	R
	15	9.3	R
	16	9.3	R
	21	9.4	R
	22	9.5	R
	23	9.9	R

200938

RS Cygni

Mo.	Day	Est.	Obs.
9	27	8.7	R
10	4	8.4	Bu
	7	8.5	R
	7	7.3	Ly
	9	7.3	R
	10	7.4	R
	11	7.6	R
	11	7.3	Le
	12	7.7	R
	13	7.7	R
	14	7.5	R
	15	7.5	R
	16	7.4	R
	17	7.4	Ma
	18	7.2	Ly
	20	8.0	Bu
	21	7.4	R
	22	7.0	Ly
	23	7.3	R

201008

R Delphini

Mo.	Day	Est.	Obs.
9	27	8.6	R
10	4	8.8	Bu
	5	9.7	R
	7	9.7	R
	8	9.2	Pi
	8	9.7	R
	10	9.6	R
	10	9.2	Bl
	11	9.5	O
	11	9.7	R
	12	9.7	R
	13	9.8	R
	14	9.9	R
	15	9.9	R
	16	9.9	R

R Delphini

Mo.	Day	Est.	Obs.
10	16	9.6	Ma
	18	9.5	O
	19	9.9	Pi
	20	9.6	Bu
	20	9.5	O
	21	9.9	R
	22	9.7	O
	23	10.0	R
	27	10.0	O

201121

RT Capricorni

Mo.	Day	Est.	Obs.
10	5	6.4	L
	7	7.4	Ly
	10	7.7	R
	11	7.7	R
	12	7.4	Ly
	12	7.4	R
	13	7.4	R
	14	7.8	R
	15	7.8	R
	16	7.7	R
	21	7.2	Ly
	21	7.7	R
	22	7.7	R
	23	7.7	R

201139

RT Sagittarii

Mo.	Day	Est.	Obs.
10	11	9.1	C
	14	9.3	C
	15	9.3	C

201647

U Cygni

Mo.	Day	Est.	Obs.
9	26	7.7	R
	27	7.7	R
10	1	7.6	R
	4	7.2	Bu
	5	7.7	R
	6	7.7	R
	7	7.7	R
	9	7.0	Ly
	9	7.0	M
	9	7.8	R
	10	7.7	R
	10	6.8	Bl
	11	7.0	C
	11	7.7	R
	12	9.2	S
	12	7.7	R
	13	7.7	R
	14	7.0	C
	14	7.8	R
	15	7.1	C
	15	7.8	R
	16	7.8	R
	18	7.0	Ly
	20	7.6	Bu
	21	7.8	R
	21	7.1	O

U Cygni

Mo.	Day	Est.	Obs.
10	21	7.3	E
	22	7.8	R
	22	6.8	Ly
	23	7.8	R
	31	6.9	M
4	5	7.1	O

202539

RW Cygni

Mo.	Day	Est.	Obs.
10	4	8.6	Bu
	9	8.4	Ly
	9	8.9	M
	10	8.5	Bl
	10	8.6	Ma
	16	8.8	Ma
	19	8.6	Ph
	20	8.8	Bu
	20	8.4	Ly
	20	8.6	Ma
	21	8.5	E
	22	8.1	Hy
	22	8.4	M
	22	8.3	Ly
	23	8.3	Hy
	25	8.6	Hy
	31	8.3	M

202817

Z Delphini

Mo.	Day	Est.	Obs.
10	11	8.7	V
	21	8.6	V

202946

SZ Cygni

Mo.	Day	Est.	Obs.
9	26	9.7	R
	27	9.3	R
10	1	9.5	R
	4	9.8	Bu
	5	9.7	R
	6	9.7	R
	7	9.3	Le
	7	9.5	R
	9	9.5	R
	9	9.3	Bl
	9	8.9	M
	10	9.1	Bl
	10	9.5	R
	10	9.0	M
	11	9.3	R
	11	9.0	Sp
	11	9.1	Le
	12	9.5	R
	13	9.6	R
	14	9.8	R
	15	9.6	R
	16	9.4	R
	18	9.8	Le
	19	9.9	Bl
	19	9.6	Hu
	20	9.4	B

VARIABLE STAR OBSERVATIONS Oct.-Nov., 1914—Continued

SZ Cygni

Mo.	Day	Est.	Obs.
10	20	9.6	Le
	20	9.8	E
	20	9.5	Ly
	21	9.6	R
	22	9.7	R
	23	9.5	R
	26	9.1	Le
	31	9.3	M
11	1	9.7	Le
	3	9.8	Le
	4	9.8	Le

202954
ST Cygni

10	10	10.5	M
	19	11.7	Hu
	20	11.7	E
	31	10.6	M

203816
S Delphini

19	10	10.7	Y
	20	10.8	Y

203847
V Cygni

10	4	9.0	Bu
	10	9.7	M
	20	9.2	Bu

204016
T Delphini

10	10	9.4	Y
	20	9.7	Y

204405
T Aquarii

10	4	8.6	Bu
	8	9.8	Ly
	8	9.6	Pi
	10	9.8	Bl
	11	10.4	Ly
	11	9.7	C
	11	9.8	Le
	12	10.0	Hy
	14	10.0	C
	15	9.7	C
	20	9.4	Bu
	21	10.6	Ly
	21	10.9	Hu
	22	10.2	Hy
	22	10.8	Pi
	23	10.6	Hy

204848
RZ Cygni

10	20	11.7	Y

205017
X Delphini

10	26	8.6	B

205923
R Vulpeculae

Mo.	Day	Est.	Obs.
10	4	9.6	Bu
	10	9.5	Bl
	12	9.1	L
	12	9.3	Ly
	19	8.9	Ly
	19	8.6	Hu
	19	8.8	E
	19	9.0	Bl
	20	9.2	Bu
	24	8.7	Ly
	31	8.0	M
11	5	8.4	O

210129
TW Cygni

10	11	10.6	V
	22	11.2	E

210116
RS Capricorni

10	4	8.2	Bu
	9	8.6	Bl
	11	8.5	Ly
	11	8.3	C
	14	8.3	C
	15	8.4	C
	21	8.6	Ly

210382
X Cephei

10	21	12.5	Y

210868
T Cephei

10	4	6.6	Bu
	6	6.7	Ma
	7	6.4	L
	7	6.7	Ly
	11	6.3	Le
	11	6.5	Ma
	11	6.7	Bg
	12	6.7	M
	12	6.8	Ly
	18	6.5	O
	19	6.4	S
	19	6.7	Ma
	20	6.6	Ly
	20	6.6	O
	20	6.4	Bu
	21	6.3	Hu
	21	6.5	E
	22	6.5	O
	24	6.4	Ly
	25	6.3	Bg
	27	6.6	O
	27	6.4	Ma
	31	6.4	M
11	5	6.4	O

211615
T Capricorn

Mo.	Day	Est.	Obs.
10	5	9.7	L

212030
S Microscopii

10	11	9.8	C
	14	9.7	C
	15	9.7	C

213244
W Cygni

9	24	6.2	L
	26	6.6	R
	27	6.8	R
	29	6.2	L
10	1	6.8	R
	4	6.4	Bu
	5	6.8	R
	6	6.8	R
	7	6.7	R
	9	6.4	L
	10	6.9	R
	11	6.8	C
	11	6.8	R
	11	6.4	Le
	12	6.3	L
	12	6.9	R
	13	6.9	R
	14	6.7	C
	14	6.9	R
	15	6.9	R
	15	6.9	C
	16	6.8	R
	18	6.8	R
	20	6.6	Bu
	22	6.9	R
	23	6.8	R

213678
S Cephei

10	11	9.0	Le
	12	9.6	M
	19	9.6	S
	21	9.6	Hu
	31	9.4	M

213753
RU Cygni

10	4	8.6	Bu
	9	8.5	Ly
	10	9.5	Bl
	20	8.6	Bu
	22	8.8	E

213843
SS Cygni

9	24	10.0	L
	26.6	10.0	R
	27.6	9.7	R
	29	9.2	L
10	1.5	8.7	Pi
	1.6	8.8	R

SS Cygni

Mo.	Day	Est.	Obs.
10	1.7	8.7	M
	1.6	9.0	J
	2	9.0	B
	2.5	8.8	J
	3	9.2	B
	4.5	8.9	M
	4.4	8.8	Bu
	5.5	9.5	J
	5.6	9.7	R
	5.4	9.4	Bu
	5	9.9	B
	6	9.7	Ly
	7	10.2	L
	7	10.2	Le
	7.6	10.0	M
	7.6	10.3	R
	8.7	11.2	M
	8	10.1	Ly
	8.5	11.5	Pi
	9	10.3	Ly
	9	10.9	L
	9.5	11.5	J
	9.6	11.2	R
	9.7	12.0	M
	10	11.5	B
	10.5	11.5	J
	11.4	11.6	J
	11.6	12.0	M
	11	11.9	Le
	12	11.7	L
	12.1	11.8	Sp
	13.1	11.9	Sp
	17.6	12.0	E
	17.5	12.0	J
	18	11.6	Ly
	18.5	12.0	J
	19.5	12.0	Hu
	19.6	11.8	E
	20.4	12.0	Hu
	20.5	11.7	E
	20	11.9	Le
	21.5	12.0	E
	21.6	12.0	J
	22.6	11.8	E
	22.5	11.9	J
	22.5	11.3	Hu
	22	11.8	Ly
	23.1	11.9	Sp
	23.5	11.9	J
	24.6	11.7	E
	24	11.7	Ly
	25.6	12.0	M
	26	12.0	Le
	27.5	11.9	J
	31.5	11.9	J
11	1	12.0	Le
	3	12.0	Le
	4	11.5	Le
	5.5	10.0	O

213937
RV Cygni

Mo.	Day	Est.	Obs.
9	27	9.1	R
10	4	6.6	Bu
	7	7.0	Ly
	8	7.3	Ma
	9	7.9	M
	9	8.1	R
	10	8.0	R
	10	7.2	Bl
	11	6.4	Le
	11	8.0	R
	12	7.9	R
	13	8.1	R
	14	8.2	R
	15	8.0	R
	16	8.2	R
	18	6.4	Le
	18	7.0	Ly
	19	7.2	Hu
	20	7.0	Bu
	20	7.2	Ma
	20	6.4	Le
	22	7.5	E
	22	8.2	R
	23	8.1	R
	26	6.4	Le
	31	7.7	M
11	1	6.4	Le
	3	6.4	Le
	4	6.4	Le

214024
RR Pegasi

10	10	12.4	B
	11	12.6	Sp

215605
V Pegasi

10	10	13.4	B
	20	13.8	B

220613
Y Pegasi

10	12	9.2	Bl
	21	9.4	O
	21	9.9	Pi

220714
RS Pegasi

10	11	9.5	V
	12	9.0	Bl
	21	9.0	O
	21	8.9	V
	21	9.5	Pi
	22	9.1	Y

222439
S Lacertae

10	20	11.8	Y
	20	12.0	E

VARIABLE STAR OBSERVATIONS Oct.-Nov., 1914.—Continued.

222557
δ Cephei

Mo.	Day	Est.	Obs.
9	26.6	3.8	R
	27.6	4.1	R
10	5.6	4.0	R
	6.7	3.8	R
	7.6	4.1	R
	9.6	4.1	R
	10.6	3.7	R
	11.6	3.8	R
	12.6	3.8	R
	13.6	3.8	R
	14.6	4.0	R
	15.6	3.7	R
	16.6	3.3	R
	17.6	3.6	R
	18.7	3.7	R
	21.7	3.6	B
	22.6	3.8	R
	23.6	4.1	R

230110
R Pegasi

Mo.	Day	Est.	Obs.
10	6	9.8	Bu
	6	10.1	Ly
	8	9.8	Pi
	10	9.9	Mu
	11	10.0	Bg
	11	9.8	Ph
	11	9.5	Ly
	11	9.9	R

R Pegasi

Mo.	Day	Est.	Obs.
10	11	9.7	O
	11	9.5	Ma
	11	9.7	Mu
	12	8.6	M
	12	8.9	Hy
	12	9.2	R
	12	9.9	Mu
	13	9.5	R
	13	9.8	Mu
	14	9.5	R
	15	9.5	R
	16	9.5	R
	16	9.4	Ma
	17	9.6	Mu
	18	9.3	O
	18	9.2	Bu
	19	9.4	Ly
	19	9.3	Pi
	20	9.0	Hu
	20	9.3	O
	21	9.5	R
	21	9.5	O
	22	8.4	Hy
	22	9.2	R
	22	9.3	Ly
	23	9.0	O
	23	9.4	R
	23	8.4	Hy

R Pegasi

Mo.	Day	Est.	Obs.
10	25	8.4	Hy
	27	9.2	O
11	5	8.8	O

230759
V Cassiop.

Mo.	Day	Est.	Obs.
10	7	10.8	Ly
	10	10.4	M
	12	11.0	Ly

231425
W Pegasi

Mo.	Day	Est.	Obs.
10	7	10.8	Ly
	11	10.8	V
	21	10.9	V

231508
S Pegasi

Mo.	Day	Est.	Obs.
10	20	10.6	O

233335
ST Androm.

Mo.	Day	Est.	Obs.
10	3	9.2	Bu
	5	8.8	B
	7	9.2	Ly
	10	9.4	Bu

ST Androm.

Mo.	Day	Est.	Obs.
10	12	9.2	Bl
	12	9.3	Ly
	18	9.2	O
	19	9.4	Ly
	20	9.0	Hu
	22	9.3	O

233815
R Aquarii

Mo.	Day	Est.	Obs.
10	3	8.6	Bu
	10	9.0	Bu
	11	7.7	Ly
	11	7.8	Ma
	12	8.1	Hy
	12	7.8	Bl
	15	8.2	R
	16	7.8	Ly
	19	7.7	Ly
	19	8.2	Ma
	22	8.0	Hy
	22	8.0	R
	23	8.2	R
	23	8.0	Hy
	25	8.0	Hy

235182
V Cephei

Mo.	Day	Est.	Obs.
10	11.6	6.5	C
	14.6	6.6	C
	15.6	6.8	C

235356
R Cassiop.

Mo.	Day	Est.	Obs.
10	5	5.5	B
	11	6.0	C
	14	6.2	C
	15	6.3	C

235525
Z Pegasi

Mo.	Day	Est.	Obs.
10	22	12.0	Y
	24	12.1	E

235939
SV Androm.

Mo.	Day	Est.	Obs.
10	18	9.6	O
	20	9.3	Hu

No. of observations, 1499; No. of stars observed, 148; No. of observers, 24.

The interesting variable 213843 SS Cygni was observed at maximum early in October, and observations indicate that it was rising again November 4. The secretary again makes the request that in the record of observations of irregular variables, such as 154428 R Cor. Bor., 074922 U Geminorum, *184205* R Scuti, 213843 SS Cygni 060547 SS Aurigae, and short period variables, the G.M.T., expressed in tenths of a day, be included. A number failed to note this request in making up this month's report.

The observations of 043274 X Camelop. are worth noting for their consistency, showing the rapid decline of 1.5 magnitude in the light of the star in eleven days.

The following zones from the list published in POPULAR ASTRONOMY for October at page 494, have been taken by the designated observers who have volunteered to cöoperate in the plan suggested by Mr. Campbell.

Zone	Observer	Zone	Observer
1	Bancroft	6	Spinney
2	Baldwin	9	Eaton
3	Olcott	12 & 13	Vrooman
4	Pickering	19	Richter

Dr. Hartwig cites the following calculated dates of maxima for the designated variables, which is a matter of interest to those observing these variables.

011208	S Piscium	Oct. 16	201008	R Delphini	Oct. 20
142584	R Camelop.	14	205923	R Vulpec.	15
165519	RY Herculis	19	213678	S Cephei	26
175458	T Draconis	9	233335	ST Androm.	19
194048	RT Cygni	14	233815	R Aquarii	25
194248	TU Cygni	14			

The secretary urges members to send in their lists so that he will receive them by the fifth or sixth of the month. Failure to do this prevents work on the report, and delays the publication of POPULAR ASTRONOMY.

The following members contributed to this report:

Messrs. Baldwin, Bolfing, Bouton, Burbeck, Craig, Eaton, Hay, Hunter, Huntington, Jacobs, Lacchini, Leonard, Lindsley, Mach, McAteer, Mundt, Olcott, Phillips Pickering, Richter, Spinney, Vrooman, Miss Swartz, Miss Young.

WILLIAM TYLER OLCOTT.
Norwich, Conn.

COMMUNICATIONS.

The Transit of Mercury.—I just now observed the transit of Mercury egress. Used finder of 3½″ telescope, and smoked glass. Time of egress, as close as I could estimate, 8:6½.

I noticed two large sun spots, almost diametrically opposite point of egress, about 7″ in from edge.

HOMER F. BLACK.

Valparaiso, Indiana, Nov. 7, 1914.

Phenomena of Jupiter's Satellites.—During September and October 1914, the writer observed three dark transits, and two conjunctions of Jupiter's satellites, which occurred as follows.

September 23, 7^h C.S.T. Observed a dark transit of satellite III, which was at that time on the central meridian. A short time before egress it became bright.

Sept. 24, 8^h 55^m. Observed the conjunction of satellites I and II. Satellite I was at that time occulted by Satellite II, making them appear as one satellite.

Sept. 30, 8^h 43^m. Observed the ingress of satellite III, which was visible as a bright disc for some time, then became invisible until 9^h 25^m, when it was again visible as a dark spot on the white equatorial cloud belt.

Oct. 4, 6^h 49^m. Observed the ingress of the shadow of I, and then, to my surprise, saw the satellite itself as a dark spot on the central meridian. The spot was as dark, and just as easy to see, as satellite III is when in transit.

Oct. 26, 6^h 30^m. Satellites I and II were again in conjunction, having the appearance of one satellite.

The above observations were made with a 6″ refractor, power 130.

J. J. SCHAFER.

Port Byron, Ill. Nov. 14, 1914.

The Transit of Mercury.—I had a fairly good view of the Transit of Mercury on the 7th inst. Though the morning was ushered in cloudy and smoky and the air filled with impurities, by 8 o'clock a. m. the opportunity for viewing the after part of the transit came about in good shape and I took advantage of it with my three-inch Bardon, with a power of 125 diameters. There were two large groups of sun spots visible, also, on the lower limb of the sun.

Just before the planet moved off of the sun and when near the edge of the sun I witnessed a phenomenon which I had never seen before at other transits, viz., an uneveness appeared on the upper rim of the planet, and almost immediately afterwards the entire planet disappeared, which was at 8:43 a.m. sun time. This, I suppose, was caused by the refraction of light and indicated a dense atmosphere on the planet. Am I right?

ISAAC N. SNYDER, SR.

A Nebular Hypothesis which will Solve the Mystery of the Glacial Period.—Acccording to the accepted theory, all the material of the universe has or had three forms of existence, vapor, liquid or solid, each form depending on the amount of heat or energy which it contained. In the formation of this world, according to the nebular hypothesis, the material of which it is formed was in existence as a vapor held in extreme expansion by heat or some form of energy convertible into heat or other forms of energy.

Since the discovery of radium there is a tendency towards a theory that all matter in its present form was derived from the ions of an original energy, forming chemical combinations which ultimately developed into the seventy or more so-called elementary bodies.

Under this conception the heat and other forms of energy must be studied from the standpoint of a chemical coefficient of the vapor and act identically as water does. As ice, water is H_2O after it loses the 79 thermal units of heat necessary to hold it as a liquid. When it becomes steam it takes 537 thermal units of heat, which becomes a chemical coefficient of the steam. As soon as it loses this latent heat it returns to its liquid form. The time may come when water may be written as a chemical formula,

Ice	H_2O
Water	H_2O Heat $_{79}$
Steam	H_2O Heat $_{79 + 537}$.

This energy filled all space, and arranged itself by law into Nebular Solar Systems, and the nebular solar systems arranged themselves into suns, planets and satellites. This theory applied to this planet assumes that it slowly cooled down and contracted as a whole, into an intensely hot mass, with our atmosphere at the circumference.

The sun is accredited with doing the same thing, and that the energy it radiates is due to contraction.

The writer thinks this theory is not entirely sound, but is based on a superficial survey of the field and overlooks a broad interpretation of known facts which will permit an entirely different conclusion. He bases his opinion on the assumption, that the laws of nature are uniform in relation to the laws which govern the vaporization, liquefaction and solidification of all substances, and what is true of one or more is true of all.

By looking at the nebular hypothesis from the standpoint of the known facts in regard to latent heat, a theory can be formulated which will solve the mystery of the early tropical climate at the poles and on the same facts explain the later glacial period.

The latent heat of steam is as intimately incorporated in the water, as if it was a chemical constituent; in no other way can this phenomenon be explained.

The heat developed by the combustion of oxygen and carbon is due to the liberation of the latent heat that holds oxygen as a gas. In all the experiments where oxygen gas is generated from its combinations, heat applied to the retort is necessary so as to supply its latent heat.

The combustion of oxygen and hydrogen liberates the latent heat of both gases, and when water is decomposed by the galvanic current, the electricity furnishes the latent heat of both gases. I can imagine that both these gases could be generated from substances which hold as a chemical coefficient a large measure of heat.

Radium is a substance whose heat and other forms of energy are held in a chemical combination. It is very probable that volcanic activity is due to the

volcanic rock holding heat energy, similar to radium, which is accumulated till the volcano gets hot enough to boil over and then becomes quiescent till enough heat is set free to bring on a new outburst.

Air has been liquefied by removing its latent heat, by first compressing it to 300 atmospheric pressures, and reducing its temperature to about 190° below zero and, if a sufficiently low temperature could be produced to remove its latent heat, of liquefaction, it would become solid.

Each and every gas we know has different meteorological points of vaporization, liquefaction and solidification, from vaporized tallow to liquid air, and it is fair to assume that the vapors of the nebulæ,would act in like manner.

Judging from geology the vapors of the granite rocks were the first to liquefy and be the first rock to reach the center of gravity. They continued doing so until the supply was exhausted, and as other vapors reached their respective meteorological points they liquefied.

It must not be overlooked that this earth's nebula was a miniature sun and acted like the sun, radiating its liberated heat and energy from its periphery, and the vapors which would be exposed to this meteorological condition would be the most rarified and for this reason would be at the periphery.

At this period the revolution of the nebula on its axis was approximately that of the moon. The substance of the moon had settled on the earth as its center of gravity, which accounts for the fact that the same side of the moon always faces the earth, and also shows that the substance of the moon was at the periphery of the nebula where it would be the first to be exposed to the conditions which favor the vapors assuming their liquid form. The attraction of gravitation of the nebula was not strong enough to draw this liquefied material to the center of gravity but instead the particles coalesced and gathered together all the material in this outer belt. All liquids assume a globular form, and this liquefied rock, submerged in its own vapor, could not lose its latent heat of liquefaction.

After the moon was formed it would leave the world nebula in a position to lose the latent heat of its vapors, which would liquify and gravitate towards the center of gravity, and in gravitating downward would carry with them the velocity of the periphery, so that when the increased velocity was balanced against the resistance at the center, it resulted in a period of 24 hours for the earth.

On the principle underlying the centrifuge, the revolution of the nebula on its axis would force the lighter gases to the circumference. Oxygen, nitrogen and hydrogen being the heaviest gases would become the earliest center of gravity after the nebula became of a globular form. These gases occupying this position shows why the moon has no atmosphere, and tends toward showing that the nebula arranged its vapors in concentric rings or blankets according to weight and density, the heaviest holding the center of gravity till they were displaced by the liquefied granite.

During the upper carboniferous period, after the lime vapors had settled down, vegetation and animal life appeared, while there still remained a thick blanket of vapors surrounding the earth, with energy enough at a close range of 45000 miles to furnish heat, light and electricity to provide a tropical climate all over the world. As I pointed out our nebular world was a miniature sun, because it was composed of the same vapors as the sun itself.

This nebular atmosphere outside our atmosphere would intercept the sun's rays. It looks to the writer as if Jupiter were in this geological period, because it has a thick opaque atmosphere which gives it apparent size without density.

After countless ages, when this nebular atmosphere began to clear so that there was no protecting blanket with radioactivity, the first part of the earth to

show it would be the poles; then the glacial period would begin and would move north and south as this belt narrowed towards the equator similar to the belts of Saturn.

If the moon, as above described, could gather the liquid rocks into a globe by the attraction of particles, our nebular atmosphere could do likewise, each vapor in succession as it became the periphery would send down its liquid rock and metals to be stratified when it fell in a segregated mass, such as we find it according to geology. This mass of each would depend on the size of the minor satellite which kept revolving around the earth until it fell, and in this way accelerated the rotation of earth on its axis.

DR. A. P. MACDONALD

Danbury, Ct.

"Discovered" Comet of 1913 (Delavan.)—On the morning of Sept. 20, when awakened in an out-door sleeping place, I first observed Comet Delavan. The Pleiades were near the meridian. The hour was between 3:00 and 4:00. I had not been giving close attention for some time to astronomical news and did not know of the comet. Though it was clearly defined, some observation was necessary, to be convinced, under the circumstances, it was not an illusion. I noted the α and δ, the latter as "9° farther from the pole than β Ursa Majoris." This I found somewhat in error. I had the good fortune to observe Comet Brooks 1911 somewhat similarly, though in the evening.

WM. B. THOMAS.

Jamestown College, Jamestown, N. Dak.

The Transit of Mercury.—I observed the transit of Mercury here with my five inch refractor. The small disc of the planet stood out intensely black on the face of the sun, in contrast to two sun spots, whose hue was distinctly lighter. The planet's outline was well defined and clean cut during the whole transit, excepting for a brief moment at the end, as it was passing off the sun. However, just after the edge of Mercury's disc touched the sun's limb, the two tiny points of the solar surface extending in to the point of contact seemed to be noticeably blurred and darkened. This phenomenon lasted less than a minute, and was difficult to observe on account of the faintness of the sun's surface at the limb. Other than this the egress presented nothing unusual, there being no appearance of the so-called "black drop."

GEORGE F. NOLTE.

Weston, Mass. Nov. 7, 1914.

GENERAL NOTES.

The article on the Lick Observatory Eclipse Expedition by Professors Campbell and Curtis has come to hand too late for this number of POPULAR ASTRONOMY but will appear in our next issue.

Professor Barnard's Photograph of Delavan's Comet.—The reproduction of the photograph of Delavan's comet in Plate XXV in the November number of POPULAR ASTRONOMY was so unsatisfactory that we asked Professor Barnard to have another block prepared under his own direction at Chicago. The print from the new block is shown in Plate XXVIII, the frontispiece to this number. This too fails to show much of the fine detail in the original photograph.

Professor Herman J. Klein, director of the Astronomical and Meteorological Observatory of Cologne, died last summer at the age of 72 years. He was well known for his popular writings on astronomy and meteorology and was editor of the journals *Sirius* and *Gaea* and the annual publication called *Jahrbuch der Astronomie und Geophysik*. Klein's Star-Atlas is also familiar to many students of astronomy.

Professor David Todd has returned to Amherst College, having made successful photographs of the corona of the recent solar eclipse from the estate of Count Bobrinsky, about a hundred miles southeast of Kieff. Owing to the mobilization, his instruments did not arrive in time, but he was able to obtain a camera and lenses that could be used. (*Science*, Nov. 13, 1914.)

Electrical Measurement of Star-Light.—*The Scientific American* for November 14, 1914, contains an interesting article by Professor Joel Stebbins, director of the Observatory at the University of Illinois, on "The Electrical Measurement of Star-Light."

Notes from Yerkes Observatory.—The conditions for observing at the Yerkes Observatory during the summer of 1914 were about normal. The number of hours of night work with the forty-inch telescope are given in the following table, which merely indicates that the sky was clear enough so that work was in progress, but does not indicate whether the steadiness was good or poor. In this respect the season was not unusual. The best "seeing" generally comes during dry weather, and therefore it is customary to give the amount of rainfall in connection with the number of hours of observation at night. There was a slight deficit in rainfall of about two inches during the three months.

HOURS OF OBSERVATION WITH 40-INCH TELESCOPE.

Month	1914	Mean for Decade
July	153	146
Aug.	140.5	148.5
Sept.	155.5	157
	RAINFALL	
July	3.00 in.	3.81 in.
Aug.	4.46	4.72
Sept.	2.58	3.56

Professor F. P. Leavenworth, of the University of Minnesota, returned to Minneapolis in the middle of October, after spending three months at the observatory. He was engaged chiefly in observing double stars and faint comets with the 40-inch telescope. Although he did not have during that time a night on which the images were of the first class, he was able to measure a considerable number of close pairs.

Mr. Alfred H. Joy, of the Syrian Protestant College, Beirut, who is now enjoying a year's leave in America, arrived at the observatory on the first of October and will remain as a member of the staff during the rest of the academic year. His principal work is the determination of parallaxes of stars with the 40-inch telescope in conjunction with Mr. Lee.

On the evening of October 10 the school teachers of Walworth County, Wisconsin, were invited to the observatory, and about 125 of them availed themselves of this opportunity. The 40-inch and 12-inch refractors and the 2-foot reflector were used for the benefit of the visitors, and a program of 10-minute lecturettes, with lantern slides, by different members of the staff, was arranged to cover the time when the visitors were not at the telescopes.

During the course of regular solar observations on September 16 one of the pinions connected with the apparatus for turning the great dome gave way, resulting in the breaking of a large gear-wheel, 40 inches in diameter. Thanks to the promptness of Messrs. Warner & Swasey, a new pinion and gear were received within eight days, but meanwhile the large dome could not be turned. This resulted very fortunately in very little loss of time, as Professor Leavenworth was able to observe double stars during their transit across the opening of the shutter, and some photographic work with short exposures could be done. Spectrographic work only had to be given up entirely during that period. Mr. Lee was able to get some excellent spectroheliograms during that interval by skillful economy of time.

A fine series of photographs of Delavan's comet has been obtained by Professor Barnard during the summer and autumn. Campbell's comet became visible here at a time when the moon was too bright to permit of successful photographs, and when the moon disappeared, the comet itself had diminished in brightness so much that interesting photographs could not be obtained. Encke's comet was rediscovered by photography by Professor Barnard on the evening of September 17. A little later it was photographed independently at Simeis, and soon after that it was photographed at Hamburg, probably also without knowledge that it had previously been found here.

During the autumn quarter Miss Jessie M. Short, Mr. Harlan T. Stetson and Mr. Edwin P. Hubble are working at the observatory.

A large room has been finished off in the attic of the observatory and iron stacks are being installed. This makes an important addition to the space for storing books and stellar photographs, and prevents the library from being overcrowded, so that it can be used for meetings and lecture purposes.

The Transit of Mercury.—The egress of Mercury from the disk of the sun on the morning of November 7 was observed by Professor H. C. Wilson with the 16-inch equatorial of Goodsell Observatory. A polarizing eyepiece with magnifying power 225 was employed. The sun was covered by thin clouds so that the seeing was poor, although not so poor as it often is at so low an altitude in clear weather. The disk of Mercury was black and round but the limb of the sun was wavy and unsteady. For this reason the time noted for third contact may be uncertain by $\pm 5^s$ and the time of fourth contact by $\pm 10^s$. As a rough check the time when the disk of Mercury appeared to be half off the sun's limb was noted. The times were noted on the chronograph.

	Local Sidereal Time	Greenwich Mean Time
Third contact	$10^h\ 58^m\ 41^s.3$	$2^h\ 07^m\ 30^s.6$
Half off	10 59 44 .7	2 08 33 .8
Fourth contact	11 00 44 .7	2 09 33 .7

The Transit of Mercury.—The transit of Mercury was observed this morning at the Creighton University Observatory in a clear sky. The image of the sun was projected on a card secured beyond the eyepiece of the equatorial. It was about five inches in diameter, while that of the planet seemed to be about a millimeter. It was about half as large as each of two spots, which were directly across the sun's center from it and half way between the center and the limb. Owing to the small size of Mercury and the low altitude of the sun, which made its image very tremulous, the last interior contact was noted 18 seconds before the computed moment and the last exterior contact about 31 seconds too late. These observations, therefore, lay no claim to accuracy.

WILLIAM F. RIGGE.

Creighton University Observatory,
Omaha, Neb. Nov. 9, 1914.

Actual Time of Signals from the U.S. Naval Observatory, October, 1914.

Day	Time of signals Noon				Time of signals 10:00 p.m.				
	h	m	s		h	m	s		
1	11	59	59.99	—.01	9	59	59.97	—.03	
2	12	00	00.00	—.00	9	59	59.98	—.02	
3	11	59	59.93	—.07	9	59	59.92	—.08	
4	11	59	59.93	—.07	9	59	59.91	—.09	Sunday
5	11	59	59.90	—.10	9	59	59.97	.03	
6	12	0	0.00	.00	10	0	0.00	.00	
7	12	0	0.02	+.02	10	0	0.02	+.02	
8	12	0	0.04	+.04	10	0	0.03	+.03	
9	12	0	0.04	+.04	10	0	0.04	+.04	
10	12	0	0.04	+.04	9	59	59.98	—.02	
11	11	59	59.97	—.03	9	59	59.95	—.05	Sunday
12	11	59	59.98	—.02	9	59	59.95	—.05	
13	11	59	59.95	—.05	9	59	59.99	—.01	
14	12	0	0.01	+.01	9	59	59.98	—.02	
15	12	0	0.00	.00	9	59	59.99	—.01	
16	12	0	0.01	+.01	9	59	59.99	—.01	
17	12	0	0.00	.00	9	59	59.99	—.01	
18	11	59	59.98	—.02	9	59	59.93	—.07	Sunday
19	12	0	0.04	+.04	9	59	59.95	—.05	
20	11	59	59.95	—.05	9	59	59.93	—.07	
21	11	59	59.92	—.08	9	59	59.99	—.01	
22	12	0	0.01	+.01	10	0	0.02	+.02	
23	11	59	59.99	—.01	10	0	0.02	+.02	
24	12	0	0.02	+.02	10	0	0.04	+.04	
25	12	0	0.04	+.04	10	0	0.07	+.07	Sunday
26	12	0	0.06	+.06	10	0	0.07	+.07	
27	12	0	0.10	+.10	10	0	0.08	+.08	
28	12	0	0.12	+.12	10	0	0.01	+.01	
29	12	0	0.03	+.03	10	0	0.00	.00	
30	12	0	0.01	+.01	10	0	0.01	+.01	
31	12	0	0.03	+.03	9	59	59.98	—.02	

(+) slow (—) fast

Maximum error: Oct. 28, +.12.

J. A. HOOGEWERFF,
Captain U. S. Navy
Superintendent.

U. S. Naval Observatory,
Washington, D. C.
November 4, 1914.

Transit of Mercury at James Observatory.—At the James Observatory, of Millsaps College, Jackson, Mississippi, the times of third and fourth contact were observed with the six-inch equatorial and with a polarizing eye-piece, power 64. The time was kept with an Elgin watch, the error and rate of which had been determined by a long series of comparisons with Central Standard Time.

The times of contact (in Greenwich mean time) were $2^h\ 7^m\ 20^s$ and $2^h\ 9^m\ 21^s$. The times computed by the formulas in the American Ephemeris and Nautical Almanac were $2^h\ 7^m\ 44^s.8$ and $2^h\ 9^m\ 58^s$ respectively.

The sky was clear though there was considerable "boiling" on the limb of the sun. A fruitless effort was made to see the planet in full after a portion had left the face of the sun.

Just before the fourth contact at three or four intervals of about five seconds rings of green light could be seen on the sun's limb in the vicinity of the planet. The color was as intense as that of a Barium salt in a Bunsen flome.

GEORGE L. HARRELL

James Observatory, Jackson, Miss., Nov. 10, 1914.

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